CHAPTER 43

Design for Occupational Health and Safety

MICHAEL J. SMITH
PASCALE CARAYON
BEN-TZION KARSH
University of Wisconsin-Madison

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1. INTRODUCTION

Each year in the United States, thousands of employees are killed on the job, many times that number die of work-related diseases, and millions suffer a work-related injury or health disorder (BLS 1998a, 1999). According to the International Labour Organization (ILO 1998), about 250 million workers worldwide are injured annually on the job, 160 million suffer from occupational diseases, and approximately 335,0000 die each year from occupational injuries. In the United States, the occupational injury and illness incidence rates per 100 full-time workers have been generally decreasing since 1973, but as of 1998, the illness and injury rate was still 6.7 per 100 employees and the injury rate was 6.2 (BLS 1998a). There were a total of 5.9 million occupational injuries and illnesses in 1998 in private industry (BLS 1998a). These figure represented the sixth year in a row of declining injury rates. Overall lost workday rates have steadily declined from 1990 to 1998, but cases with days of restricted work activity have increased. There were just over 60000 occupational fatalities in the private sector in 1998. These work-related deaths and injuries have enormous costs. In the United States alone, it was estimated that in 1992 the direct costs (e.g., medical, property damage) totaled $65 billion and the indirect costs (e.g., lost earnings, workplace training and restaffing, time delays) totaled $106 billion (Leigh et al. 1997). Of the U.S. dollar figures presented, approximately $230 million of the direct costs and $3.46 billion of the indirect costs were related to fatal occupational injuries. Nonfatal injuries accounted for $48.9 billion in direct costs and $92.7 billion in indirect costs (the rest was cost due to death and morbidity from occupational illnesses). These estimates assumed 6500 occupational fatalities and 13.2 million nonfatal injuries.

The workplace continues to undergo rapid change with the introduction of new technologies and processes. Many new processes, such as genetic engineering and biotechnology, introduce new hazards that are challenging, particularly since we do not know much about their potential risks. Will current hazard-control methods be effective in dealing with these new hazards? Our challenge is to protect workers from harm while taking advantage of the benefits of this new technology. To achieve this, we must be ready to develop new safety and health methods to deal with new technology.

This chapter will examine the causation and prevention of occupational diseases and injuries, with an emphasis on recognizing and evaluating hazards, determining disease/injury potential, and defining effective intervention strategies. Due to the huge amount of pertinent information on each of these topic, it cannot be all inclusive. Rather, it will provide direction for establishing effective detection and control methods. Additional resources are provided in the Appendix for more detailed information about the subjects covered.

2. INTERDISCIPLINARY NATURE OF OCCUPATIONAL SAFETY AND HEALTH

Occupational health and safety has its roots in several disciplines, including such diverse fields as engineering, toxicology, epidemiology, medicine, sociology, psychology, and economics. Essentially, occupational health and safety is a multidisciplinary endeavor requiring knowledge from diverse sources to deal with the interacting factors of people, technology, the work environment, and the organization of work activities. Any successful approach for the prevention of injuries and health disorders must recognize the need to deal with these diverse factors using the best available tools from various disciplines and to organize a systematic and balanced effort. Large companies have many resources that can be called upon, but small companies do not have such resources and may need to contact local, state, and federal agencies for information, advice, and consultation.

3. A PUBLIC HEALTH MODEL FOR OCCUPATIONAL SAFETY AND HEALTH PROTECTION

Figure 1 illustrates a general public health approach for improving the safety and health of the workforce (HHS 1989). It begins with surveillance. We have to know what the hazards are and their safety and health consequences before we can establish priorities on where to apply our limited resources and develop intervention strategies. At the national level, there are statistics on occupational

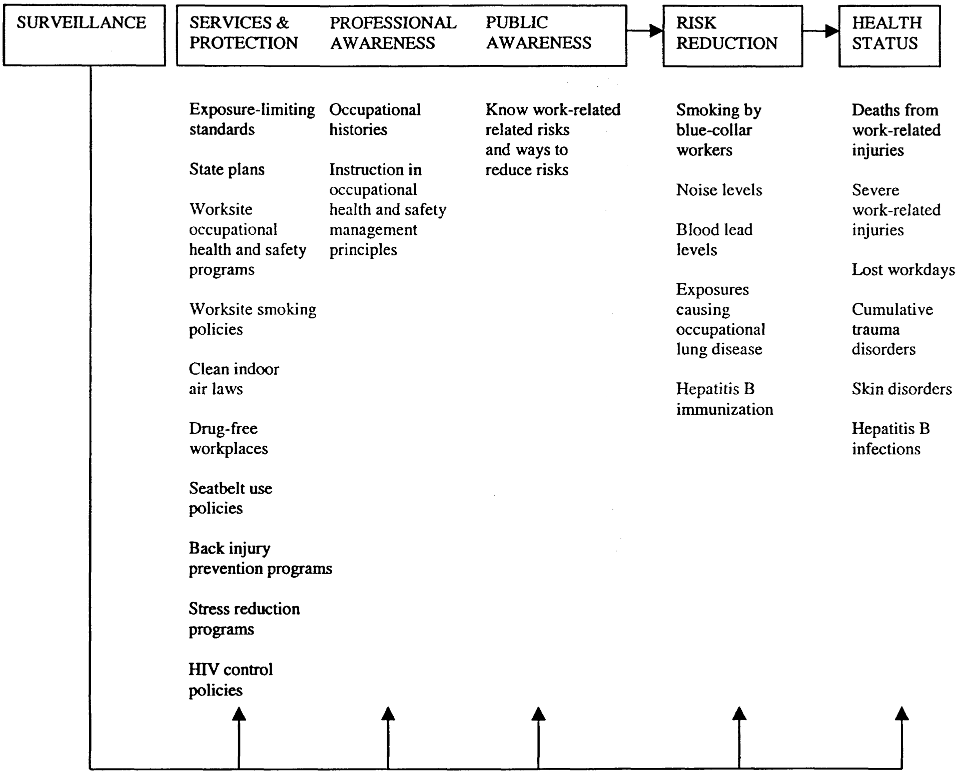

Figure 1 A Public Health Model for Improving the Safety and Health of the Workforce. (*Source:* HHS 1989)

injuries and illnesses from various sources including the U.S. Bureau of Labor Statistics, U.S. National Center for Health Statistics, and National Safety Council. These statistics provide an indication of the most hazardous jobs and industries. In addition, each state has workers' compensation statistics that can provide information about local conditions. This same kind of surveillance can be done by each company at the plant level to identify hazardous jobs and operations. Plant level exposure, hazard, and injury/illness records can be examined periodically to establish trends and determine plant hot spots that need immediate attention.

The second level of the model defines specific services and protection measures to prevent the occurrence of hazards and injuries/illnesses. It also includes services for quick and effective treatment if injury or illness should occur. For example, the safety staff keep track of the state and federal requirements regarding workplace exposure standards. The safety staff then establishes a process for enforcing the standards through inspections and correction activities. Additional plant safety and health programs deal with employee safety and health training (Cohen and Colligan 1998), emergency medical treatment facilities, and arrangements with local clinics. The basic thrust of these multifaceted approaches is to reduce or eliminate adverse workplace exposures and their consequences and provide effective treatment when injuries and illnesses occur.

At the next level of the model is the need to heighten the awareness of the professionals in the workplace who have to make the decisions that affect safety, such as the manufacturing engineers, accountants, operations managers, and supervisors. In addition, workers need to be informed so that they know about the risks and consequences of occupational exposures. There is substantial workplace experience to attest that managers and employees do not always agree on the hazardous nature of workplace exposures. It is vital that those persons who can have a direct impact on plant exposures, such as managers and employees, have the necessary information in an easily understandable and useful form to be able to make informed choices that can lead to reductions in adverse exposures. Providing the appropriate information is the first basic step for good decision making. However, it does not ensure good decisions. Knowledgeable and trained professionals are also needed to provide proper advice on how to interpret and use the information.

The next stage in the model is the reduction of risk by having known adverse agents of injury or illness controlled or removed. The reduction in risk leads to the final stage, which is an improvement in health and safety status of the workforce. This general model leads to a more specific approach that can be applied at specific workplaces.

4. A BALANCE MODEL OF OCCUPATIONAL SAFETY AND HEALTH PERFORMANCE

An important consideration in conceptualizing an approach to occupational health and safety is an understanding of the many personal and workplace factors that interact to cause exposures and accidents. Any strategy to control these exposures and accidents should consider a range of factors and their influences on each other. A model of human workplace interaction is presented in Figure 2. Each element of this model can produce hazardous exposures, for instance a work environment with chemical exposures. These elements also interact to produce hazardous exposures. Examples of these interactions are when high-workload tasks are performed in environments with chemical exposures creating greater fatigue, or more inhalation of the chemicals. Another example is when the person uses machinery and tools that have hazardous characteristics and there is high work pressure to complete the task quickly. Then, the potential for an acute injury increases. Each single factor of the balance model has specific characteristics that can influence exposures to hazards and accident potential or disease risk. At the same time, each interacts with the others to increase exposures and risks or reduce exposures and risks. The model indicates that the person is exposed to loads and hazards that create acute or chronic strains. These strains can lead directly to injury or illness, or they may increase accident potential and/or disease risk.

4.1. The Person

A wide range of individual attributes can affect exposure and accident potential. These include intellectual capabilities and aptitudes, perceptual–motor abilities, physical capabilities such as strength and endurance, current health status, susceptibilities to disease, and personality. A person's education, knowledge, and aptitude affect his or her ability to recognize hazards. They also influence how much a person will learn from training about hazards and safety. An important aspect of injury prevention is to have knowledgeable employees who can determine the potential danger of an exposure and respond appropriately. This requires some previous experience with a hazard and/or training about the nature of the hazard, its injury potential, and ways to control it. Employees must have the ability to learn and retain the information that they are given in training classes. There is a fundamental need for employees to have adequate background and education to be able to apply their intelligence and acquire new knowledge through training. Of specific importance are reading and language skills

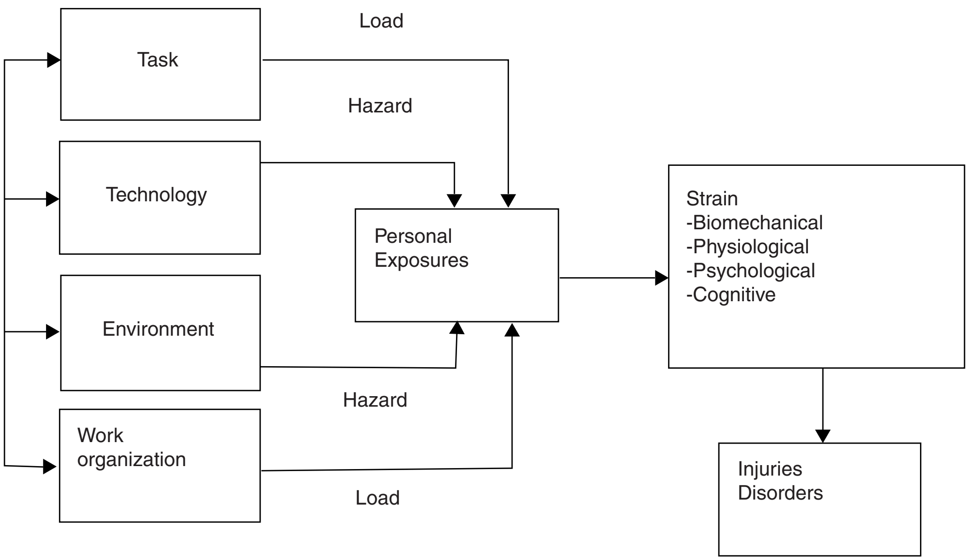

Figure 2 Model of the Work System Risk Process. (Adapted from Smith and Sainfort 1989; Smith et al. 1999)

so that employees can be trained and instructed properly. When employees lack sufficient intelligence or knowledge-acquisition skills, much greater emphasis must be placed on engineering controls.

Physiological considerations such as strength, endurance, and susceptibilities to fatigue, stress, or disease are also of importance. Some jobs demand high energy expenditure and strength requirements. For these, employees must have adequate physical resources to do the work safely.

Another example deals with a concern about women being exposed to reproductive hazards in select industries, for instance in lead processing or synthetic hormone production. Biological sensitivity to substances may increase the risk of an adverse health outcome. Where adequate protection can be provided, there is no logical reason to exclude employees on the basis of gender or biological sensitivity. However, with certain exposures the courts in the United States have ruled that biologically sensitive employees may be barred from jobs in which these biologically adverse exposures cannot be adequately controlled or guarded against.

An attribute related to physical capacity is the perceptual/motor skills of an individual, such as eye–hand coordination. These skills vary widely among individuals and may have more health and safety significance than strength or endurance because they come into play in the moment-by-moment conduct of work tasks. While strength may influence the ability to perform a specific component of a task, perceptual/motor skills are involved in all aspects of manual tasks. Thus, perceptual/motor skills affect the quality with which a task is carried out as well as the probability of a mistake that could cause an exposure or accident.

An individual attribute that should also be considered is personality. For many years it was believed that an employee's personality was the most significant factor in accident causation and that certain workers were more "accident prone" than other workers. There is some evidence that "affectivity" is related to occupational injuries (Iverson and Erwin 1997). However, in an earlier review of the accident proneness literature (Century Research Corp. 1973), it was determined that individual characteristics such as personality, age, sex, and intellectual capabilities were not significant determinants of accident potential or causation. Rather, situational considerations such as the hazard level of the job tasks and daily personal problems were more important in determining accident risk. There is some evidence that individuals are at greater or lesser risk at different times in their working careers due to these situational considerations. Such situational considerations may account for findings that younger and older employees have higher than average injury rates (Laflamme 1997; Laflamme and Menckel 1995).

It is critical that a proper fit be achieved among employees and other elements of the model. This can occur with proper hazard orientation, training, skill enhancement, ergonomic improvements, and proper engineering of the tasks, technology, and environment.

4.2. Technology and Materials

As with personal attributes, characteristics of the machinery, tools, technology, and materials used by the worker can influence the potential for an exposure or accident. One consideration is the extent to which machinery and tools influence the use of the most appropriate and effective perceptual/motor skills and energy resources. The relationship between the controls of a machine and the action of that machine dictates the level of perceptual/motor skill necessary to perform a task. The action of the controls and the subsequent reaction of the machinery must be compatible with basic human perceptual/motor patterns. If not, significant interference with performance can occur which may lead to improper responses that can cause accidents. In addition, the adequacy of feedback about the action of the machine affects the performance efficiency that can be achieved and the potential for an operational error.

The hazard characteristics of materials will affect exposure and risk. More hazardous materials inherently have a greater probability of adverse health outcomes upon exposure. Sometimes employees will be more careful when using materials that they know have a high hazard potential. But this can only be true when they are knowledgeable about the material's hazard level. If a material is very hazardous, often less-hazardous materials available can be substituted. The same is true for hazardous work processes. Proper substitution can decrease the risk of injury or illness, but care must be taken to ensure that the material or process being substituted is really safer and that it mixes well with the entire product formulation or production/assembly process.

4.3. Task Factors

The demands of a work activity and the way in which it is conducted can influence the probability of an exposure or accident. In addition, the influence of the work activity on employee attention, satisfaction, and motivation can affect behavior patterns that increase exposure and accident risk. Work task considerations can be broken into the physical requirements, mental requirements, and psychological considerations. The physical requirements influence the amount of energy expenditure necessary to carry out a task. Excessive physical requirements can lead to fatigue, both physiological and mental, which can reduce worker capabilities to recognize and respond to workplace hazards.

Typically, relatively high workloads can be tolerated for short periods of time. However, with longer exposure to heavy workloads and multiple exposures to shorter-duration heavy workloads, fatigue accumulates and worker capacity is diminished.

Other task considerations dealing with the content of the task that are related to the physical requirements include the pace or rate of work, the amount of repetition in task activities, and work pressure due to production demands. Task activities that are highly repetitive and paced by machinery rather than by the employee tend to be stressful. Such conditions also diminish an employee's attention to hazards and the capability to respond to a hazard due to boredom. These conditions may produce cumulative trauma disorders to the musculoskeletal system when the task activity cycle time is short and constant. Tasks with relatively low workload and energy expenditure can be very hazardous due to the high frequency of muscle and joint motions and boredom, which leads to employee inattention to hazards.

Psychological task content considerations, such as satisfaction with job tasks, the amount of control over the work process, participation in decision making, the ability to use knowledge and skills, the amount of esteem associated with the job, and the ability to identify with the end products of the task activity, can influence employee attention and motivation. They can also cause job stress, which can affect employee ability to attend to, recognize, and respond to hazards as well as the motivation needed to be concerned with their health and safety considerations. Negative influences can bring about emotional disturbances that limit the employee's capabilities to respond. Task considerations are a central aspect in reducing worker fatigue and stress and enhancing worker motivation for positive health and safety behavior. Tasks must be designed to fit the workforce capabilities and needs and be compatible with the other elements of the model.

4.4. The Work Environment

The work environment exposes employees to materials, chemicals, and physical agents that can cause harm or injury if the exposure exceeds safe limits. Such exposures vary widely from industry to industry, from job to job, and from task to task. Hazard exposure in the work environment influences the probability of an injury or illness, and the extent of exposure often determines the seriousness. Differences in hazard potential are a central basis for determining the rates companies pay for workers' compensation insurance. The central concept is one of relative risk. The greater the number of hazards, the more serious their potential to inflict injury or illness, then the greater the probability of an accident. The greater the probability of a serious accident, the higher the insurance premium. The hazard potential of different environmental factors can be evaluated using various federal, state, and local codes and standards for worker protection and limits established by scientific groups.

Environmental conditions can also hamper the ability of employees to use their senses (poor lighting, excessive noise) and reduce an employee's abilities to respond or react to a hazardous situation. Moderate levels of noise, high levels of heat, and the presence of dust/fumes or gases/vapors have been linked to higher risk of occupational fatalities (Barreto et al. 1997). The environment should be compatible with worker perceptual/motor, energy expenditure, and motivational needs to encourage hazard recognition, precautions, and the desire to do tasks in the proper way.

4.5. Organizational Structure

A company's health and safety performance can be influenced by management policies and procedures, the way that work tasks are organized into plant-wide activities, the style of employee supervision, the motivational climate in the plant, the amount of socialization, interaction between employees, the amount of social support employees receive, and management attitude towards safety. The last point, management attitude, has often been cited as the most critical element in a successful safety program (Cohen, 1977; Smith et al. 1978; Cleveland et al. 1979). If the individuals who manage an organization have a disregard for safety considerations, then employees tend not be very motivated to work safely. Conversely, if the management attitude is that safety considerations are paramount, that is, even more important than production goals, then managers, supervisors, and employees will put great diligence into health and safety efforts.

There are other organizational considerations important in safety performance that are related to management atmosphere and attitudes. For instance, a management structure that provides for frequent employee interaction, positive supervisor relations, and frequent social support leads to an organizational climate that is conducive to cooperative efforts in hazard recognition and control. Such a structure also allows for the motivational climate necessary to encourage appropriate safety behavior. Supervisor and coworker social support have been shown to reduce the risk of occupational injuries (Iverson and Erwin 1997).

A consistent factor in accident causation is work pressure for greater production, or faster output, or to correct problems quickly to continue production or reduce customer waiting time. This work pressure can be exacerbated by technology malfunctions, insufficient staffing, and improper work standards. Management emphasis on reducing costs, enhancing profits, and increasing stock price often stretch the limits of the capabilities of the workforce and technology. When breakdowns occur or operations are not running normally, employees tend to take risks to keep production online or get it back online quickly. It is during these nonnormal operations that many accidents occur.

Management must provide adequate resources to meet production goals and accommodate nonnormal operations. Management must also establish policies to ensure that employees and supervisors do not take unnecessary risks to ensure production.

5. SAFETY AND HEALTH ORGANIZATIONS, AGENCIES, LAWS, AND REGULATIONS

History has shown that ensuring the safety and health of the workforce cannot be left solely to the discretion of owners and employers. There are those who take advantage of their position and power and do not provide adequate safeguards. Today this is true for only a small percentage of employers but unfortunately, even well-intentioned employers sometimes expose the workforce to hazardous conditions through ignorance of the risks. Factory safety laws were enacted in Europe in past centuries to deal with employer abuses. The basic concepts were adopted in the United States when some of the states took action in the form of factory laws and regulations, both for worker safety and for compensation in case of injury. Over the years these laws were strengthened and broadened until 1969 and 1970, when the U.S. Congress created two federal laws regulating safety and health for those employers engaged in interstate commerce in coal mining and all other private industry. In 1977, federal legislation dealing with other forms of mining was added. However, public institutions such as state and local governments and universities were not covered by the federal laws in the United States and still are not covered by federal safety legislation.

The Occupational Safety and Health Act of 1970 (OSHAct) remains the primary federal vehicle for ensuring workplace safety and health in the United States. This law requires that employers provide a place of employment free from recognized hazards to employee safety or health. The critical word is ‘‘recognized’’ because today’s workplaces have many new materials and processes for which hazard knowledge is absent. This places a large responsibility on the employer to keep abreast of new knowledge and information about workplace hazards for their operations. The OSHAct established three agencies to deal with workplace safety and health. These were the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and the Occupational Safety and Health Review Commission.

5.1. The Occupational Safety and Health Administration

OSHA, located within the U.S. Department of Labor, has the responsibility for establishing federal workplace safety and health standards and enforcing them. Over the last three decades, OSHA has developed hundreds of standards that have been published in the code of federal regulations (CFR) Section 29 CFR, subsections 1900–1928, which cover General Industry (1910), Longshoring (1918), Construction (1926), and Agriculture (1928) (http://www.osha-slc.gov/OshStd_toc/OSHA_Std_toc.html). This code is revised periodically and new standards are added continually. Current and proposed rules and standards include Process Safety Management of Highly Hazardous Chemicals (1910.119), Personal Protective Equipment (1910.132 to 1910.139), the Proposed Safety and Health Program Rule, and the Final Ergonomic Program Standard. It is important for employers to keep up with these new and revised standards. One way is to keep in frequent contact with your area office of OSHA and request that they send you updates. Another way is to subscribe to one or more of the many newsletters for occupational safety and health that provide current information and updates. A third way is to access the OSHA web page (http://www.osha.gov), which provides information about current activities, regulations, and updates.

Workplaces are required by law to be in compliance with the federal safety and health standards. Failure to do so can be the basis for federal fines in the first instance, meaning that when a violation is found, the inspector will propose a fine and an abatement period. Under some of the former state safety programs, an identified hazard did not bring a fine if it was controlled within the abatement period. Under the federal process, fines will be assessed immediately after a hazard is identified. These fines can be substantial, and the threat of such fines is felt to be an incentive for compliance with the federal standards. Many employers feel that this first-instance fine is punitive and takes resources away from abatement efforts. However, the logic of first-instance fines is to motivate employers to be proactive in looking for and correcting workplace hazards. If an employer is found to be in violation of a standard and disagrees with the inspector about this, the employer has the right to a review at higher OSHA levels. If no recourse is obtained from OSHA, then the employer has the right for review by the Occupational Safety and Health Review Commission. The employer also has the right to subsequent legal recourse through the federal courts.

Current estimates of the numbers of OSHA inspectors and workplaces indicate that the average workplace can expect an OSHA inspection about every 9 to 10 years. To apply its inspection resources in the most effective manner, OSHA has adopted a strategy to concentrate on the most hazardous industries. Thus, these industries can expect an inspection much more often. OSHA concentrates on select high-risk industries, such as construction, and select injuries, such as cumulative trauma, which is widespread in meat processing and assembly jobs. OSHA has contracted with several state workers' compensation agencies to obtain data on the employers in these states with the greatest injury frequency and severity and uses these data to select employers for inspection. Inspections can also be triggered by a complaint from an employee or employee representative. When the inspector arrives at your workplace, you will be shown an official credential indicating that the inspector is from OSHA. It is a good policy to cooperate with the OSHA inspector. However, at the initial contact by the inspector you have the right, by ruling of the U.S. Supreme Court, to require a search warrant for entry into your workplace. Most employers provide immediate access to their facilities because requiring a search warrant may create an antagonistic situation once the warrant is obtained by the inspector.

When an inspection is triggered by a complaint, the inspector will typically only examine the hazard(s) and work areas defined in the complaint. If it is a general inspection, usually the entire workplace is examined. The first step in the inspection is a review of your injury and illness log (OSHA 300). The inspector will be looking for jobs or areas of the plant that have many injuries and illnesses. After this, the inspector will conduct a walk-through of the facility. You have the right to accompany the inspector on the inspection and point out trade secrets that you want to be kept confidential. OSHA will meet your request unless there is good reason to believe that your trade secret is not really a secret. A representative of your employees is also allowed to accompany the inspector. During the inspection the inspector will talk to employees about their working conditions and any safety and health problems they are encountering. The inspector will take notes on what is observed and heard. Some inspections are complex and require special measurements of the equipment, air contamination, noise level, or other aspects of hazard exposure. Depending on the size of the plant or store location and the number of hazards, an inspection can take from one day up to several months. At the end of the inspection, the inspector will have a closing conference with management and the employee representative to discuss what was observed and possible violations of the standards. If standards were violated, some days after the inspection you will receive a formal citation indicating the standards violated and proposed penalties via registered mail. At that time you can contest any of the proposed violations and/or penalties. These will be reviewed with you by the OSHA area director and some agreement may be reached at that time. If not, you can contest to higher levels in OSHA, and then to the Occupational Safety and Health Review Commission. The final recourse is the federal courts.

OSHA also provides professional training and short courses to safety and health professionals, employee representatives, and employees at the OSHA Training Institute and through contracts with universities, colleges, technical schools, and unions. See the OSHA website for information on training (http://www.osha.gov).

5.2. The National Institute for Occupational Safety and Health

NIOSH is a subunit of the Centers for Disease Control and Prevention (see website http://www.cdc.gov), which conducts research into the causes and cures of occupationally caused injuries and illnesses. It also has a training function that promotes the development of occupational safety and health professionals. NIOSH research covers a broad range of topics, from the toxicology of chemicals, metals, and biological agents to the causes of accidents to the psychological stress aspects of the workplace, to name a few. The results of this research are published in the scientific literature and public reports disseminated by NIOSH and the U.S. Government Printing Office. A listing of these reports is available on the NIOSH website (http://www.cdc.gov/niosh). Oftentimes enough research knowledge is accumulated to develop a recommendation for a federal safety and health standard. At that time a criteria or technical document is developed that defines the scope of the hazard(s), the evidence for adverse safety or health effects, and recommendations for exposure limits and control mechanisms. These criteria documents and technical reports are sent to OSHA for consideration as the basis for a safety and health federal standard. They also often appear in court litigation as the state-of-the-art knowledge about the hazards of products in product liability suits, even though they may not have been adopted as standards. Information on these criteria documents and NIOSH research reports is available from the U.S. Superintendent of Documents in Washington, DC, and from the NIOSH website.

NIOSH also conducts health hazard investigations in situations where employees become ill from unknown causes or where they have been exposed to agents for which only scarce knowledge is available and special expertise is needed. These investigations are triggered by a request for technical assistance from OSHA, a state health agency, a state safety agency, or a health hazard evaluation request from a company, union, or employee. NIOSH has a right of entry into workplaces for these investigations but can be required to obtain a search warrant by the company. These investigations are often much more complex than OSHA investigations and can entail extensive environmental measurement, employee physical examinations and interviews, examinations of company records, and discussions with management. Reports are developed based on the evaluation, which include a determination of hazards and proposed methods of control. These reports may be sent to OSHA for compliance action (inspection and/or citation).

5.3. State Agencies

The state(s) in which your operation(s) are located may also have jurisdiction for enforcing occupational safety and health standards, and conducting investigations based on an agreement with OSHA. In many states the state health agency and/or labor department has agreements with OSHA to provide consultative services to employers. You can find out by contacting these agencies directly. In several states the safety and health agencies enforce safety and health rules and standards for local and state government employees, or other employees not covered by OSHA. See website http://www.cdc.gov/niosh/statosh.html.

5.4. Centers for Disease Control and Prevention

The purpose of the Centers for Disease Control and Prevention (CDC) is to promote health and quality of life by preventing and controlling disease, injury, and disability. The CDC provides limited information on occupational safety and health. For example, their web page has information about accident causes and prevention, back belts, cancer—occupational exposure, effects of workplace hazards on male reproductive health, latex allergies, needle stick, occupational injuries, teen workers, and violence in the workplace (see website http://www.cdc.gov). The Center for Health Statistics is located within CDC and provides basic health statistics on the U.S. population. This information is used to identify potential occupational health risks by occupational health researchers (see website http://www.cdc.gov/nchs).

5.5. The Bureau of Labor Statistics

The Bureau of Labor Statistics (BLS) is the principal fact-finding agency for the federal government in the broad field of labor economics and statistics (see website http://stats.bls.gov). It collects, processes, analyzes, and disseminates essential statistical data. Among the data are occupational safety and health data, including annual reports, by industry, of rates of injuries, illnesses, and fatalities (http://stats.bls.gov/oshhome.htm).

5.6. The Environmental Protection Agency

The Environmental Protection Agency (EPA) was established as an independent agency in 1970 with the purpose of protecting the air, water, and land (see website http://www.epa.gov). To this end, the EPA engages in a variety of research, monitoring, standard setting, and enforcement activities. The Agency administers 10 comprehensive environmental protection laws: the Clean Air Act (CAA); the Clean Water Act (CWA); the Safe Drinking Water Act (SDWA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund); the Resource Conservation and Recovery Act (RCRA); the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); the Toxic Substances Control Act (TSCA); the Marine Protection, Research, and Sanctuaries Act (MPRSA); Uranium Mill Tailings Radiation Control Act (UMTRCA); and the Pollution Prevention Act (PPA). The EPA's Strategic Plan for the 21st century includes 10 goals, among which is one dealing with preventing pollution and reducing risk in communities, homes, workplaces, and ecosystems. For the purposes of this chapter, we will focus on the issues related to workplaces. According to the EPA's plan (EPA 1999), over 75,000 chemicals are in commerce today, with an estimated 2,000 new chemicals and 40 genetically engineered microorganisms introduced each year. Among those are potentially toxic chemicals that may present risks to workers, such as persistent, bioaccumulative and toxic chemicals (PBTs). Reducing PBTs should lead to safer manufacturing processes and eliminate some occupational exposures. Strategies to deal with such chemicals include better management of, training about, and reduced use of pesticides; better programs to deal with the chemical industry; industrial pollution prevention; better building construction to promote quality indoor air; and industrial waste minimization.

5.7. Other Agencies and Groups

The American National Standards Institute (ANSI) was founded in 1918 and has been the administrator and coordinator of the United States private sector voluntary standardization system (see website http://www.ansi.org). ANSI does not itself develop standards but rather facilitates development by establishing consensus among qualified groups. ANSI has developed a number of occupational health- and safety-related standards, including standards related to information management for occupational safety and health (ANSI Z16.2-1995), preparation of hazardous industrial chemical material safety data sheets (ANSI Z400.1-1998), construction safety and health audit programs (ANSI A10.39-1996), and human factors engineering of visual display terminal workstations (ANSI/HFS 100-1988).

The mission of the American Society for Testing and Materials (ASTM) is to be the foremost developer and provider of voluntary consensus standards, related technical information, and services having internationally recognized quality and applicability that (1) promote public health and safety, (2) contribute to the reliability of materials, products, systems and services, and (3) facilitate national, regional, and international commerce. See website http://www.astm.org.

The International Labour Organization (ILO) was created in 1919 and is a United Nations (UN) specialized agency that seeks the promotion of social justice and internationally recognized human and labor rights (see webpage http://www.ilo.org). The ILO formulates minimum standards of basic labor rights, such as freedom of association, the right to organize, and collective bargaining. It also provides technical assistance in areas such as vocational training and vocational rehabilitation, employment policy, working conditions, and occupational safety and health. There is a branch concerned with occupational safety and health (see website http://www.ilo.org/public/english/protection/safework/intro.htm) that focuses on reducing the number and seriousness of occupational accidents and diseases, adapting the working environment, equipment, and work processes to the physical and mental capacity of the worker, enhancing the physical, mental, and social well being of workers in all occupations, encouraging national policies and programs of member states, and providing appropriate assistance. To achieve those aims, the ILO works with government and nongovernment agencies to design and implement policies and programs to improve working conditions. The ILO is currently working on a global program for occupational safety and health.

The constitution of the World Health Organization (WHO) was approved in 1946 (see website http://www.who.org). Its goal is good health for all people. To this end, the WHO directs international health activity, promotes technical cooperation, helps governments strengthen their own health services, provides technical assistance, conducts research, and establishes international standards for biological and pharmaceutical products. They also provide information on global occupational safety and health issues (see website http://www.who.org/peh/Occupational_health/occindex.html), such as biological agents, noise, radiation, chemicals, occupational carcinogens, and allergenic agents. WHO established the international statistical classification of diseases and related health problems in occupational health. The organization has a global strategy on occupational safety and health that includes 10 priority areas:

1. Strengthening international and national policies for health at work and developing necessary policy tools
2. Developing healthy work environments
3. Developing healthy work practices and promoting health at work
4. Strengthening occupational health services
5. Establishing support services for occupational health
6. Developing occupational health standards
7. Developing human resources for occupational health
8. Establishing registration and data systems, developing information services, and raising public awareness
9. Strengthening research
10. Developing collaboration in occupational health with other services

The European Agency for Safety and Health at Work (see website http://europe.osha.eu.int/) was established in 1996 and is based in Bilbao, Spain. The Agency has put forth numerous directives for employers in its member states to follow. These include general safety requirement directives, directives regarding temporary workers, pregnant workers, and young people and directives on manual handling, work equipment, and safety signs. The agency also conducts information campaigns, such as the recently launched campaign aimed at reducing the number of work-related back injuries and other musculoskeletal disorders. Other information about occupational health and safety in the European Union can be found using HASTE (see website http://www.occuphealth.fi/e/eu/haste/), the European Union health and safety database, which lists databases from member states.

5.8. Safety and Ergonomics Program Standards

The purpose of the OSHA Proposed Safety and Health Program Rule (see website http://www.osha-slc.gov/SLTC/safetyhealth/nshp.html) is to reduce the number of job-related fatalities, illnesses, and injuries by requiring employers to establish a workplace safety and health program to ensure compliance with OSHA standards and the General Duty Clause of the OSHAct. All employers covered under the OSHAct are covered by this rule (except construction and agriculture), and the rule applies to all hazards covered by the General Duty Clause and OSHA standards. Five elements make up the program:

1. Management leadership and employee participation
2. Hazard identification and assessment
3. Hazard prevention and control
4. Information and training
5. Evaluation of program effectiveness

Employers that already have safety and health programs with these five elements can continue using their existing programs if they are effective. Late in 2000, OSHA announced its Final Ergonomic Program Standard (see website http://www.osha-slc.gov/ergonomics-standard/index.html). The proposed Standard specifies employer's obligations to control musculoskeletal disorder (MSD) hazards and provide MSD medical management for injured employees. The Proposed Ergonomic Standard uses a program approach—that is, the proposal specifies the type of a program to set up to combat MSD, as opposed to specifying the minimum or maximum hazard levels. According to the proposed ergonomic standard, an ergonomic program consists of the following six program elements:

1. Management leadership and employee participation
2. Hazard information and reporting
3. Job hazard analysis and control
4. Training
5. MSD management
6. Program evaluation

These are similar to the elements in the proposed safety and health program rule. The proposed ergonomics standard covers workers in general industry, though construction, maritime, and agriculture operations may be covered in future rulemaking. The proposal specifically covers manufacturing jobs, manual material-handling jobs, and other jobs in general industry where MSDs occur. If an employer has an OSHA recordable MSD, the employer is required to analyze the job and control any identified MSD hazards. Public hearings were ongoing regarding the proposed ergonomic standard as of March–April of 2000 and written comments were being taken. Some states have proposed ergonomic standards to control MSDs.

The California Ergonomic Standard (see website http://www.dir.ca.gov/Title8/5110.html) went into effect on July 3, 1997. The standard targets jobs where a repetitive motion injury (RMI) has occurred and the injury can be determined to be work related and at a repetitive job. The injury must have been diagnosed by a physician. The three main elements of the California standard are work site evaluation, control of exposures that have caused RMIs, and employee training. The exact language of the standard has been undergoing review in the California judicial system.

The purpose of the Washington State Proposed Ergonomics Program Rule (see website http://www.lni.wa.gov/wisha) is to reduce employee exposure to workplace hazards that can cause or aggravate work-related musculoskeletal disorders (WMSDs). There are no requirements for medical management in the proposed rule. The proposal covers employers with caution zone jobs, which the proposed rule defines based on the presence of any one or more of a number physical job factors. For example, a caution zone job exists if the job requires "working with the neck, back or wrist(s) bent more than 30 degrees for more than 2 hours total per workday" (WAC 296-62-05105). The proposed standard specifies the type of ergonomic awareness education that must be provided to employees who work in caution zone jobs. The standard also states that if caution zone jobs have WMSD hazards, employers must reduce the WMSD hazards identified. Several tools are suggested that can be used to analyze the caution zone jobs for WMSD hazards, and thresholds are provided that indicate sufficient hazard reduction. The rule also states that employees should be involved in analyzing caution zone jobs and in controlling the hazards identified. This proposed rule was under review in 2000.

The proposed North Carolina Ergonomic Standard (see website http://www.dol.state.nc.us/news/ergostd.htm) was first announced in November 1998. Like the proposed national standard and California's standard, North Carolina's is a program standard without physical hazard thresholds. The proposal states employers shall provide ergonomic training within 90 days of employment and no less than every three years thereafter. It also specifies the nature of that training, which includes information on ergonomic physical hazards, MSDs that can arise from ergonomic hazards, workplace ways to control ergonomic hazards, and the importance of reporting symptoms. Under the proposed standard, if an MSD is thought to be causally related to work, the employer has to implement

TABLE 1 Descriptions of NIOSH Top Eight Occupational Disease and Injury Categories

Disease or Injury	Description
Allergic and irritant dermatitis	Allergic and irritant dermatitis (contact dermatitis) is overwhelmingly the most important cause of occupational skin diseases, which account for 15% to 20% of all reported occupational diseases. There is virtually no occupation or industry without potential exposure to the many diverse agents that cause allergic and irritant dermatitis.
Asthma and chronic obstructive pulmonary disease	Occupationally related airway diseases, including asthma and chronic obstructive pulmonary disease (COPD), have emerged as having substantial public health importance. Nearly 30% of COPD and adult asthma may be attributable to occupational exposure. Occupational asthma is now the most frequent occupational respiratory disease diagnosis. More than 20 million U.S. workers are exposed to substances that can cause airway diseases.
Fertility and pregnancy abnormalities	While more than 1000 workplace chemicals have shown reproductive effects in animals, most have not been studied in humans. In addition, most of the 4 million other chemical mixtures in commercial use remain untested. Physical and biological agents in the workplace that may affect fertility and pregnancy outcomes are practically unstudied.
Hearing loss	Occupational hearing loss may result from an acute traumatic injury, but it is far more likely to develop gradually as a result of chronic exposure to ototraumatic (damaging to the ear or hearing process) agents. Noise is the most important occupational cause of hearing loss, but solvents, metals, asphyxiants, and heat may also play a role. Exposure to noise combined with other agents can result in hearing losses greater than those resulting from exposure to noise or other agents alone.
Infectious disease	Health care workers are at risk of tuberculosis (TB), hepatitis B and C viruses, and the human immunodeficiency virus (HIV). Social service workers, corrections personnel, and other occupational groups who work regularly with populations having increased rates of TB may also face increased risk. Laboratory workers are at risk of exposure to infectious diseases when working with infective material.
Low-back disorders	Back pain is one of the most common and significant musculoskeletal problems in the world. In 1993, back disorders accounted for 27% of all nonfatal occupational injuries and illnesses involving days away from work in the United States. The economic costs of low back disorders are staggering. According to NIOSH (1996b), a recent study showed the average cost of a workers' compensation claim for a low-back disorder was $8,300, which was more than twice the average cost of $4075 for all compensable claims combined. Estimates of the total cost of low-back pain to society in 1990 were between $50 billion and $100 billion per year, with a significant share (about $11 billion) borne by the workers' compensation system. Moreover, as many as 30% of American workers are employed in jobs that routinely require them to perform activities that may increase risk of developing low-back disorders.
Musculoskeletal disorders of the upper extremities	Musculoskeletal disorders of the upper extremities (such as carpal tunnel syndrome and rotator cuff tendinitis) due to work factors are common and occur in nearly all sectors of our economy. More than $2 billion in workers' compensation costs are spent annually on these work-related problems. Musculoskeletal disorders of the neck and upper extremities due to work factors affect employees in every type of workplace and include such diverse workers as food processors, automobile and electronics assemblers, carpenters, office data-entry workers, grocery store cashiers, and garment workers. The highest rates of these disorders occur in the industries with a substantial amount of repetitive, forceful work. Musculoskeletal disorders affect the soft tissues of the neck, shoulder, elbow, hand, wrist, and fingers.

TABLE 1 (*Continued*)

Disease or Injury	Description
Traumatic injuries	During the period 1980 through 1992, more than 77,000 workers died as a result of work-related injuries. This means that an average of 16 workers die every day from injuries suffered at work. The leading causes of occupational injury fatalities over this 13-year period were motor vehicles, machines, homicides, falls, electrocutions, and falling objects. In four industries—mining, construction, transportation, and agriculture—occupational injury fatality rates were notably and consistently higher than all other industries. In 1994, 6.3 million workers suffered job-related injuries that resulted in lost work time, medical treatment other than first aid, loss of consciousness, restriction of work or motion, or transfer to another job. The leading causes of nonfatal occupational injuries involving time away from work in 1993 were overexertion, contact with objects or equipment, and falls to the same level.

engineering controls, work practice controls, and/or administrative controls to reduce the impact of the ergonomic hazards. Employee participation in the ergonomic program is encouraged.

6. DEFINING OCCUPATIONAL INJURIES AND DISEASES

Early in the 1980s, NIOSH defined the 10 most serious occupational disease and injury areas (CDC 1983). These were occupational lung diseases, musculoskeletal injuries, occupational cancers, acute trauma, cardiovascular diseases, disorders of reproduction, neurotoxic disorders, noise-induced hearing loss, dermatologic conditions, and psychological disorders. In April of 1996, NIOSH developed the National Occupational Research Agenda (NORA) (NIOSH 1996a), which identified 21 priority research areas to target and coordinate occupational safety and health research. Eight of the 21 target areas focus on occupational diseases and injuries. This was an update of the list from the early 1980s defined above. The new list identifies allergic and irritant dermatitis, asthma and chronic obstructive pulmonary disease, fertility and pregnancy abnormalities, hearing loss, infectious disease, low-back disorders, musculoskeletal disorders of the upper extremities, and traumatic injuries (NIOSH 1996b) as serious problems. More detail on each disease or condition is provided in Table 1. Table 2 provides brief descriptions of various types of occupational diseases and injuries not included in Table 1 that were highlighted previously by CDC and NIOSH.

7. WORKPLACE HAZARDS

A list of all currently recognized and potential workplace hazards would be larger than this entire Handbook. The best places to start accumulating hazard information pertinent to your operations are the OSHA standards, NIOSH criteria documents, and government reports and publications. These are available on the websites listed in this chapter and from the U.S. Superintendent of Documents in Washington, DC. The websites have a great deal of useful information. Other excellent sources of information include the National Safety Council Safety manuals, NIOSH (1984), and Best's Loss Control Guide. Other federal, state, and local agencies can also provide some aspects of occupational health and safety hazard information. At the federal level these include the Environmental Protection Agency (EPA), the National Institute for Environmental Health Sciences (NIEHS), and the Centers for Disease Control and Prevention (CDC).

It is important to comprehend the breadth and nature of occupational hazard exposures. To do this we can classify workplace hazard sources into broad categories that help us to understand their nature and potential controls. These are:

1. Physical agents such as noise and heat
2. Powered mechanical agents such as machinery and tools
3. Nonpowered mechanical agents such as hammers, axes, and knives
4. Liquid chemical agents such as benzene and toluene
5. Powdered materials such as pesticides, asbestos, sand, and coal dust
6. Gaseous or vaporous chemical agents such as nitrous oxide, carbon monoxide, and anhydrous ammonia

TABLE 2 Descriptions of Various Occupational Disorders and Diseases Not Included in Table 1

Disease or Injury	Description
Occupational lung disease	The latent period for many lung diseases can be several years. For instance, for silicosis it may be as long as 15 years and for asbestos-related diseases as long as 30 years. The lung is a primary target for disease related to toxic exposures because it is often the first point of exposure through breathing. Many chemicals and dusts are ingested through breathing. The six most severe occupational lung disorders are asbestosis, byssinosis, silicosis, coal workers' pneumoconiosis, lung cancer, and occupational asthma.
Asbestosis	This disease produces scarring of the lung tissue, which causes progressive shortness of breath. The disease continues to progress even after exposures end, and there is no specific treatment. The latent period is 10–20 years. The agent of exposure is asbestos, and insulation and shipyard workers are those most affected.
Byssinosis	This disease produces chest tightness, cough, and airway obstruction. Symptoms can be acute (reversible) or chronic. The agents of exposure are dusts of cotton, flax, and hemp, and textile workers are those most affected.
Silicosis	This is a progressive disease that produces nodular fibrosis, which inhibits breathing. The agent of exposure is free crystalline silica, and miners, foundry workers, abrasive blasting workers, and workers in stone, clay, and glass manufacture are most affected.
Coal Miners' pneumoconiosis	This disease produces fibrosis and emphysema. The agent of exposure is coal dust. The prevalence of this disorder among currently employed coal miners has been estimated at almost 5%.
Lung cancer	This disease has many symptoms and multiple pathology. There are several agents of exposure, including chromates, arsenic, asbestos, chloroethers, ionizing radiation, nickel, and polynuclear aromatic hydrocarbon compounds.
Occupational cancers	There is some debate on the significance of occupational exposures in the overall rate of cancer ranging from 4 to 20% due to occupation, yet there is good agreement that such occupational exposures can produce cancer. There are many types of cancer that are related to workplace exposures, including hemangiosarcoma of the liver; mesothelioma; malignant neoplasm of the nasal cavities, bone, larynx, scrotum, bladder, kidney, and other urinary organs; and lymphoid leukemia and erythroleukemia.
Traumatic injuries Amputations	The vast majority of amputations occur to the fingers. The agents of exposure include powered hand tools and powered machines. Many industries have this type of injury, as do many occupations. Machine operators are the single most injured occupation for amputations.
Fractures	Falls and blows from objects are the primary agents that cause fractures. The major sources of these injuries include floors, the ground, and metal items. This suggests falling down or being struck by an object as the primary reasons for fractures. Truck drivers, general laborers, and construction laborers were the occupations having the most fractures.
Eye loss	It was estimated that in 1982 there were over 900,000 occupational eye injuries. Most were due to particles in the eye such as pieces of metal, wood, or glass, but a smaller number were caused by chemicals in the eye. A number of occupations are affected, including those in woodworking, metalwork, construction, and agriculture.

TABLE 2 **(*Continued*)**

Disease or Injury	Description
Traumatic injuries	
Lacerations	Over 2,000,000 lacerations occur each year with the majority to the fingers, followed by the arms, legs, and head/neck. Lacerations occur primarily from being struck or stuck by an object or from striking against an object. The major agents of exposure include knives, sharp metal objects, saws, glass items, nails, and machines.
Cardiovascular disease	These disorders include hypertensive disease, ischemic heart disease, other forms of heart disease, and cerebrovascular disease. As with cancer, the specific contribution of occupational factors to the causation of CVD has been debated, but there is agreement that some workplace factors contribute to or cause CVD (see Smith and Sainfort 1990 for a detailed discussion of psychosocial factors and their contribution). Four main occupational sources of CVD causation are agents that affect cardiopulmonary capacity, chemicals, noise, and psychosocial stress.
Cardiopulmonary capacity reducers	Agents such as dusts, mists, heavy metals, silica, and other trace elements make the lungs work much harder than normal and can induce congestive heart failure. Metal such as beryllium, antimony, lead, and cobalt as well as silica and asbestos can produce heart disorders.
Chemicals	Some chemicals act to sensitize the heart muscle and the smooth muscle of the blood vessels, while others reduce the oxygen-carrying capacity of the blood. These include nitroglycerin, carbon monoxide, carbon disulfide, and halogenated hydrocarbons.
Noise	Studies have shown that noise can produce transient increases in blood pressure that may lead to CVD. This may be due to psychological factors related to stress reactions.
Psychosocial stress	Research from longitudinal studies of cardiovascular fitness has demonstrated a relationship between perceived job satisfaction and stress and cardiovascular illness. Epidemiological studies have shown that particular jobs with specific characteristics such as high demands and low control have a higher incidence of coronary heart disease. Organizational demands and relations, job task demands, social relationships at work, work schedule, work content features, discretionary control and participation, and physical working conditions have all been shown to influence the level of job stress (Smith 1986; Kalimo et al. 1997).
Neurotoxic disorders	Neurotoxic disorders are produced by damage to the central nervous system, damage to the peripheral nervous system, and intoxication. These cause deficits in attention, reasoning, thinking, remembering, and making judgments. They may also cause peripheral neuropathy, neuroses and psychoses, personality changes, aberrant behavior, or reduced reaction time and motor skill. One of the first workplace-related neurological disorders identified was lead poisoning, which produced palsy in workers exposed to lead dust. NIOSH publishes a list of the materials known to have neurotoxic effects.
Psychological disorders	Psychological disorders related to working conditions include sleep disturbances, mood disturbances, reduced motivation to work or recreate, somatic and psychosomatic complaints, neuroses, psychoses, and dysfunctional coping behavior. The effects of stress on an individual are influenced by the nature of the exposures and the individual's physical and psychological characteristics and coping behaviors that may accentuate or mitigate the exposure.

7. Heavy metals such as lead and mercury
8. Biological agents such as bacteria and viruses
9. Genetically engineered agents
10. Other hazards, such as wet working surfaces, unguarded floor openings, job stress, and the unsafe behavior of others

These hazards enter the body through various avenues, including inhalation into the lungs and nose, absorption through the skin and other membranes, ingestion into the throat and stomach, traumatic contact with various body surfaces and organs, and, in the case of job stress, through the cognitive mental processes. Descriptions of many of these hazards and definitions of adverse exposure levels are contained in NIOSH (1977).

Traditional hazards such as unexpected energy release and chemicals are still major concerns in the workplace. The use of lasers, robots, microwaves, x-rays, and imaging devices will become more common and will make many of the traditional problems of controlling energy release and limiting worker access to hazardous machine components even more challenging. These technologies will be even more problematic because of the complex nature of the mechanisms of energy release and the increased power of the forces involved. For instance, using x-rays for lithographic etching of computer chips could produce exposures that are substantially higher than with conventional diagnostic x-rays. The safety precautions for this type of instrument have to be much better than current standards for diagnostic equipment.

In addition to these emerging hazards, other new hazards will appear. Some will be the exotic products of genetic engineering and biotechnology, while others will be the products of our ability to harness the laws of physics and chemistry with advanced engineering designs. The future will see commercial uses of plasma gas generators for tool hardening, electron accelerators for generating tremendous power for x-ray lithography in microchip production and fusion power generation. These will become everyday tools used by thousands of workers, many of whom will not be well educated or knowledgeable about the tremendous power of the technology they will be working with.

While these physical and biological hazards will become more prevalent and dangerous than they are today, there will also be more physical and psychological work demands that can lead to psychological stress problems. Currently, the two fastest-rising workers' compensation claim areas in the United States are cumulative musculoskeletal trauma and psychological distress. The rise in these problems can generally be related to two factors: first, greater media, worker, and employer awareness and knowledge about how the workplace can contribute to such problems; and second, huge increases in workplace automation that create conditions that produce these disorders. Dealing with these stress-induced problems may be even more difficult than dealing with the biological, chemical, and physical hazards.

8. MEASURING HAZARD POTENTIAL AND SAFETY PERFORMANCE

To control occupational hazards and related illness and injuries, it is necessary to define their nature and predict when and where they will occur. This requires that some system of hazard detection be developed that can define the frequency of the hazard, its seriousness, and its amenability to control. Traditionally, two parallel systems of information have been used to attain this purpose. One is hazard identification, such as plant inspections, fault-free analysis, and employee hazard-reporting programs, which have been used to define the nature and frequency of company hazards. In this case, action is taken before an injury or illness occurs. The second system is after the fact in that it uses employee injury and company loss-control information to define problem spots based on the extent of injuries and costs to the organization. When pre- and postinjury systems have been integrated, they have been successful in predicting high-risk plant areas or working conditions where remedial programs can be established for hazard control.

8.1. Inspection Programs

Hazard identification prior to the occurrence of an occupational injury is a major goal of a hazard inspection program. In the United States, such programs have been formalized in terms of federal and state regulations that require employers to monitor and abate recognized occupational health and safety hazards. These recognized hazards are defined in the federal and state regulations that provide explicit standards of unsafe exposures. The standards can be the basis for establishing an in-plant inspection program because they specify the explicit subject matter to be investigated and corrected.

Research has shown that inspections are most effective in identifying permanent fixed physical and environmental hazards that do not vary over time. Inspections are not very effective in identifying transient physical and environmental hazards or improper workplace behaviors because these hazards may not be present when the inspection is taking place (Smith et al. 1971). A major benefit from inspections, beyond hazard recognition, is the positive motivational influence on employees. Inspections demonstrate management interest in the health and safety of employees and a commitment to a safe working environment. To capitalize on this positive motivational influence, an inspection should not be a punitive or confrontational process of placing blame. Indicating the good aspects of a work area and not just the hazards is important in this respect. It is also important to have employees participate in hazard inspections because this increases hazard-recognition skills and increases motivation for safe behavior.

The first step in an inspection program is to develop a checklist that identifies all potential hazards. A good starting point is the state and federal standards. Many insurance companies have developed general checklists of OSHA standards that can be tailored to a particular plant. These are a good source when drawing up the checklist. A systematic inspection procedure is preferred. This requires that the inspectors know what to look for and where to look for it and have the proper tools to conduct an effective assessment. It is important that the checklist be tailored to each work area after an analysis of that work area's needs has been undertaken. This analysis should determine the factors to be inspected: (1) the machinery, tools, and materials, (2) chemicals, gases, vapors, and biological agents, and (3) environmental conditions. The analysis should also determine (1) the frequency of inspections necessary to detect and control hazards, (2) the individuals who should conduct and/or participate in the inspections, and (3) the instrumentation needed to make measurements of the hazard(s).

The hazards that require inspection can be determined by (1) their potential to cause an injury or illness, (2) the potential seriousness of the injuries or illnesses, (3) the number of people exposed to the hazard, (4) the number of injuries and illnesses at a workplace related to a specific hazard, and (5) hazardous conditions defined by federal, state, and local regulations. The frequency of inspections should be based on the nature of the hazards being evaluated. For instance, once a serious fixed physical hazard has been identified and controlled, it is no longer a hazard. It will only have to be reinspected periodically to be sure the situation is still no longer hazardous. Random spot checking is another method that can indicate whether the hazard control remains effective. Other types of hazards that are intermittent will require more frequent inspection to assure proper hazard abatement. In most cases, monthly inspections are warranted, and in some cases daily inspections are reasonable.

Inspections should take place when and where the highest probability of a hazard exists, while reinspection can occur on an incidental basis to ensure that hazard control is effectively maintained. Inspections should be conducted when work processes are operating, and on a recurring basis at regular intervals. According to the National Safety Council (1974), a general inspection of an entire premises should be conducted at least once a year, except for those work areas scheduled for more frequent inspections because of their high hazard level. Because housekeeping is an important aspect of hazard control, inspection of all work areas should be conducted at least weekly for cleanliness, clutter, and traffic flow. The National Safety Council (1974) indicated that a general inspection should cover the following:

1. Plant grounds
2. Building and related structures
3. Towers, platforms, or other additions
4. Transportation access equipment and routes
5. Work areas
6. Machinery
7. Tools
8. Materials handling
9. Housekeeping
10. Electrical installations and wiring
11. Floor loading
12. Stairs and stairways
13. Elevators
14. Roofs and chimneys

We would add to this:

15. Chemicals, biological agents, radiation, etc.
16. Ergonomic stressors
17. Psychosocial stressors

Intermittent inspections are the most common type and are made at irregular intervals, usually on an ad hoc basis. Such inspections are unannounced and are often limited to a specific work area or process. Their purpose is to keep first-line supervisors and workers alert to safety considerations and hazard detection. Such inspections do not always require a checklist. Systematic informal inspections made by first-line supervisors on a daily basis in their work area can be effective in identifying intermittent hazards and also keeping employees aware of good safety practices. Continuous inspections occur when employees are aware of safety considerations and detect and report hazards as they occur. Maintenance staff can also play a role in defining hazardous conditions while carrying out their duties of machinery repair.

As indicated above, all employees in an organization can become involved in inspecting for hazards, some formally, some informally. Technical, periodic health and safety inspections should be conducted by the plant medical, industrial hygiene, and safety staff. These persons have special expertise to define and evaluate hazards. That expertise can be supplemented by outside experts from insurance companies, government safety and health agencies, and private consultants. Conducting a formal inspection requires some planning and structure. First it must be determined what, where, and when to inspect. That decision will be based on hazard and illness/injury potential. A determination must be made whether to give prior warning to the employees in the area to be inspected. If hazards are primarily behavioral in nature, the prior warning may reduce the effectiveness of the inspection.

When conducting the inspection, the department supervisor should be asked to identify hot spots or special problem areas. A checklist can be used to identify each hazard and its nature, exact location, potential to cause serious damage, and possible control measures. During the walk-through, employee input should be solicited. Photographs and videotapes of hazards are effective in documenting the nature and potential seriousness of hazards. Once the inspection is completed, a report should be prepared that specifies pertinent information about the nature of the hazards, illness and injury potential, and abatement recommendations. This report needs to be detailed and provide step-by-step instructions for instituting hazard-control procedures in a timely manner. First, all potential hazards and their contributors should be listed. Second, the hazard identification analysis should provide solutions to deal with the hazards. The methods used to conduct the hazard identification should produce accurate estimates for the risks of harm to employees. Finally, resources should be allocated for abating the hazards and should be prioritized by those safety improvements that should yield the best results, that is, the best safety performance.

It is not sufficient simply to write up the results; they should be shared with all parties concerned in a face-to-face meeting. This meeting will give the results greater significance and serve as the basis for further interaction and possible modification of recommendations. Such meetings will enhance employee understanding and allow for in-depth discussions of the findings and recommendations. This makes the entire inspection process more relevant to supervisors and employees and facilitates the favorable acceptance of the results and any subsequent recommendations.

The quality of a hazard-identification system can be evaluated by answering the following four questions (Suokas 1993):

1. How well has the analysis identified hazards and their contributors?
2. How effectively has the analysis produced potential solutions needed in the system?
3. How accurately has the analysis estimated the risks of the system?
4. What is the cost-effectiveness of the hazard identification analysis?

8.2. Illness and Injury Statistics

There are four main uses of injury statistics: (1) to identify high-risk jobs or work areas, (2) to evaluate company health and safety performance, (3) to evaluate the effectiveness of hazard-abatement approaches, and (4) to identify factors related to illness and injury causation. An illness and injury-reporting and analysis system requires that detailed information must be collected about the characteristics of illness and injuries and their frequency and severity. The Occupational Safety and Health Act (1970) established illness and injury reporting and recording requirements that are mandatory for all employers, with certain exclusions such as small establishments and government agencies. Regulations have been developed to define how employers are to adhere to these requirements (BLS 1978).

The OSHAct requirements specify that any illness or injury to an employee that causes time lost from the job, treatment beyond first aid, transfer to another job, loss of consciousness, or an occupational illness must be recorded on a daily log of injuries and illnesses, the OSHA 300 form (previously the 200 form). This log identifies the injured person, the date and time of the injury, the department or plant location where the injury occurred, and a brief description of the occurrence of the injury, highlighting salient facts such as the chemical, physical agent, or machinery involved and the nature of the injury. An injury should be recorded on the day that it occurs, but this is not always possible with MSDs and other cumulative trauma injuries. The number of days that the person is absent from the job is also recorded upon the employee's return to work. In addition to the daily log, a more detailed form is filled out for each injury that occurs. This form provides a more detailed description of the nature of the injury, the extent of damage to the employee, the factors that could be related to the cause of the injury, such as the source or agent that produced the injury, and events surrounding the injury occurrence. A workers' compensation form can be substituted for the OSHA 301 form (previously the 101 form) because equivalent information is gathered on these forms.

The OSHA Act injury and illness system specifies a procedure for calculating the frequency of occurrence of occupational injuries and illnesses and an index of their severity. These can be used by companies to monitor their health and safety performance. National data by major industrial categories are compiled by the U.S. Bureau of Labor Statistics annually and can serve as a basis of comparison of individual company performance within an industry. Thus, a company can determine whether its injury rate is better or worse than that of other companies in its industry. This industry-wide injury information is available on the OSHA website (http://www.osha.gov).

The OSHA system uses the following formula in determining company annual injury and illness incidence. The total number of recordable injuries is multiplied by 200,000 and then divided by the number of hours worked by the company employees. This gives an injury frequency per 100 person hours of work (injury incidence). These measures can be compared to an industry average.

$$\text{Incidence} = \frac{\text{number of recordable injuries and illnesses} \times 200{,}000}{\text{number of hours worked by company employees}}$$

where The number of recordable injuries and illnesses is taken from the OSHA 300 daily log of injuries.
The number of hours worked by employees is taken from payroll records and reports prepared for the Department of Labor or the Social Security Administration.

It is also possible to determine the severity of company injuries. Two methods are typically used. In the first, the total number of days lost due to injuries is compiled from the OSHA 300 daily log and divided by the total number of injuries recorded on the OSHA 300 daily log. This gives an average number of days lost per injury. In the second, the total number of days lost is multiplied by 200,000 and then divided by the number of hours worked by the company employees. This gives a severity index per 100 person hours of work. These measures can also be compared to an industry average.

Injury incidence and severity information can be used by a company to monitor its injury and illness performance over the years to examine improvement and the effectiveness of health and safety interventions. Such information provides the basis for making corrections in the company's approach to health and safety and can serve as the basis of rewarding managers and workers for good performance. However, it must be understood that injury statistics give only a crude indicator of safety company performance and an even cruder indicator of individual manager or worker performance. This information can be used to compare company safety performance with the industry average.

Because injuries are rare events, they do not always reflect the sum total of daily performance of company employees and managers. Thus, while they are an accurate measure of overall company safety performance, they are an insensitive measure at the individual and departmental levels. Some experts feel that more basic information has to be collected to provide the basis for directing health and safety efforts. One proposed measure is to use first-aid reports from industrial clinics. These provide information on more frequent events than the injuries required to be reported by the OSHAct. It is thought that these occurrences can provide insights into patterns of hazards and/or behaviors that may lead to the more serious injuries and that their greater number provides a larger statistical base for determining accident potential.

8.3. Incident Reporting

Another approach is for a company to keep track of all accidents whether an illness or injury is involved or not. Thus, property damage accidents without illness or injury would be recorded, as would near accidents and incidents that almost produced damage or injury. The proponents of this system feel that a large database can be established for determining accident-causation factors. As with the first-aid reports, the large size of the database is the most salient feature of this approach. A major difficulty in both systems is the lack of uniformity of recording and reporting the events of interest. The method of recording is much more diffuse because the nature of the events will differ substantially from illnesses or injuries, making their description in a systematic or comparative way difficult.

This critique is aimed not at condemning these approaches but at indicating how difficult they are to define and implement. These systems provide a larger base of incidents than the limited occurrences in injury-recording systems. The main problem is in organizing them into a meaningful pattern. A more fruitful approach than looking at these after-the-fact occurrences may be to look at the conditions that can precipitate injuries, that is, hazards. They can provide a large body of information for a statistical base and can also be organized into meaningful patterns.

9. CONTROLLING WORKPLACE HAZARDS

With the workplace hazards identified and defined, the next logical step is to eliminate or control them. Historically, there have been two predominant concepts about hazard controls. The first concept is to think of hazard control as a hierarchy of methods of control. In the hierarchy, the best control method is to eliminate the hazard through redesign or substitution. If elimination or substitution cannot be achieved, then the next-best approach is to block employee access to the hazard. Finally, if blocking cannot be achieved, then a last approach would be to warn the employees of the hazard and train them how to avoid the hazard.

A second way to conceptualize hazard control is in terms of the type of control: engineering controls, human factors controls, and organizational controls. Engineering controls include modifying the technology, workstation, tools, environment, or other physical aspects of work to eliminate, remove, substitute, or block access to the hazard.

Human factors controls deal with fitting the work activity to the employee's capabilities. Organizational controls involve things such as improving work procedures and practices, providing training, rotating employees to reduce the amount of exposure, and providing rest breaks designed to reduce the impact of hazards. All of these types of controls are not mutually exclusive and should be used together to achieve hazard reductions.

9.1. Engineering Controls

It would seem that the simplest way to deal with a hazard would be to get rid of it. This can be accomplished by redesigning a product, tool, machine, process, or environment or through substitution of a nonhazardous or less hazardous material or machine. For example, the loading of a mechanical punch press can be accomplished by placing a part directly onto the die with the employee's hand, which puts the hand directly into the point of operation. If the press should inadvertently cycle, the employee could injure his or her hand. To eliminate this hazard, a fixture can be designed so that the employee can place the part onto the fixture and then slide the fixture with the part into the point of operation. Thus, the fixture and not the employee's hand goes into the point of operation. This redesign removes the hand from the hazardous area of the machine. Likewise, a barrier guard could be put over the point of operation so that the employee's hand could not fit into the danger zone. This will be discussed in the next paragraph. Another example is substituting a less hazardous chemical for a more hazardous chemical, thereby reducing the extent of risk or the level of exposure.

The second class of engineering interventions is blocking employee access to the hazard. This can be achieved by putting up a barrier that keeps the employee from entering a hazardous area. The best example of this is fencing off an area such as high-voltage transformers. With this type of intervention, the hazard remains but access to the hazard is limited. However, often the hazardous area must be accessed for maintenance or other reasons. In this case, there are often secondary hazard controls to protect those who cross the barrier. For example, robots usually have a barrier around them to keep employees outside of their arc of swing so that they do not inadvertently come into contact with the robot's arm. But when the robot has to be programmed or maintained, an employee has to go across the barrier to access the robot. A secondary control is to have the robot automatically shut down when the barrier is breached. This is a form of interlock that keeps the hazard inactive while employees are present in the danger zone. In the case of many hazards, such as the high-voltage transformer, it may not be possible to have a secondary hazard control. Then we must rely on the knowledge, skills, and good sense of the employee and/or the person breaching the barrier. These human factor controls will be discussed below.

Containment is a form of a barrier guard that is used primarily with very dangerous chemical and physical hazards. An example is the ionizing radiation from a nuclear reactor. This radiation at the core of the reactor is restrained from leaving the reactor by lead-lined walls, but if leakage should occur through the walls, a back-up barrier contains the leakage. In the case of a closed system, the employee never comes in contact with the source (such as the reactor core) of the hazard. The system is designed through automation to protect the employee from the hazard source. Many chemical plants use the concept of a closed system of containment. The only time an employee would contact these specific deadly hazards would be in the case of a disaster in which the containment devices failed.

Another form of barrier control that looks something like a secondary hazard control is a guard, which is used to cover moving parts that are accessible by the employees—for example, inrunning nip points on a machine. Such guards are most often fixed and cannot be removed except for maintenance. Sometimes the guard needs to be moved to access the product. For example, when a power press is activated, there is a hazard at the point of operation. When the ram is activated, guards are engaged that prohibit an employee's contact with the die. When the ram is at rest, the guard can be lifted to access the product. If the guard is lifted, an interlock prohibits the ram from being activated. In this situation, there is a barrier to keep the employee from the area of the hazard only when the hazard is present. The guard allows access to the area of the hazard for loading, unloading, and other job operations that can be carried out without activation. But when the machine energy is activated, the guard moves into place to block the employee from access to the site of the action. In the case of the robot, the hazard area is quite large and a perimeter barrier is used; but in the case of a mechanical press, the hazard area is limited to the point of operation, which is quite small.

Yet another engineering control that is important for dealing with workplace hazards is the active removal of the hazard before it contacts the employee during the work process. An example is a local scavenger ventilation system that sucks the fumes produced by an operation such as spot welding or laser surgery away from the employees. This exhausts the fumes into the air outside of the plant (surgery room) and away from the employees. The ventilation systems must comply with federal, state, and local regulations in design and in the level of emissions into the environment. Thus, the fumes may need to be scrubbed clean by a filter before being released into the open environment. A related ventilation approach is to dilute the extent of employee exposure to airborne contaminants by bringing in more fresh air from outside the plant on a regular basis. The fresh air dilutes the concentration of the contaminant to which the employee is exposed to a level that is below the threshold of dangerous exposure. The effectiveness of this approach is verified by measuring the ambient air level of contamination and employee exposure levels on a regular basis. When new materials or chemicals are introduced into the work process or when other new airborne exposures are introduced into the plant, the adequacy of the ventilation dilution approach to provide safe levels of exposure(s) must be reverified. (See Hagopian and Bastress 1976 for recommendations for ventilation guidelines.)

When guarding or removal systems (e.g., saw guards, scavenger and area ventilation) cannot provide adequate employee protection, then personal protective equipment (PPE) must be worn by the employees (safety glasses, respirator). Because it relies on compliance by the employees, this is not a preferred method of control. A cardinal rule of safety and health engineering is that the primary method of controlling hazards is through engineering controls. Human factors controls are to be used primarily when engineering controls are not practical, feasible, solely effective in hazard control, or cost effective. It is recognized that human factor controls are often necessary as adjuncts (supplements) to engineering controls and in many instances are the only feasible and effective controls.

9.2. Human Factors Controls

In the traditional scheme of hazard control, there are two elements of human factors considerations for controlling hazards: warning and training. These can also be conceptualized as informing employees about hazards and promoting safe and healthful employee behavior. Cohen and Colligan (1998) conducted a literature review of safety training effectiveness studies and found that occupational safety and health training was effective in reducing employee hazard risks and injuries.

9.2.1. Informing

Informing employees about workplace hazards has three aspects: the right to know, warnings, and instructions. Regarding the right to know, federal safety and health regulations and many state and local regulations (ordinances) specify that an employer has the obligation to inform employees of hazardous workplace exposures to chemicals, materials, or physical agents that are known to cause harm. The local requirements of reporting vary and employers must be aware of the reporting requirements in the areas where they have facilities. Generally, an employer must provide information on the name of the hazard, its potential health effects, exposure levels that produce adverse health effects, and the typical kinds of exposures encountered in the plant. In addition, if employees are exposed to a toxic agent, information about first aid and treatment should be available. For each chemical or material or physical agent classified as toxic by OSHA, employers are required to maintain a standard data sheet that provides detailed information on its toxicity, control measures, and standard operating procedures (SOPS) for using the product. A list of hazardous chemicals, materials, and physical agents is available from your local OSHA office or the OSHA website (http://www.osha.gov). These standard data sheets (some are referred to as material safety data sheets [MSDS]) must be supplied to purchasers by the manufacturer who sells the product. These data sheets must be shared by employers with employees who are exposed to the specific hazardous products, and must be available at the plant (location) as an information resource in case of an exposure or emergency. The motivation behind the right-to-know concept is that employees have a basic right to knowledge about their workplace exposures and that informed employees will make better choices and use better judgment when they know they are working with hazardous materials.

Warnings are used to convey the message of extreme danger. They are designed to catch the attention of the employee, inform the employee of a hazard, and instruct him or her in how to avoid the hazard. The OSHA regulations require that workplace warnings meet the appropriate ANSI standards, including Z35.1-1972 specifications for accident prevention signs; Z35.4-1973 specifications for informational signs complementary to ANSI Z35.1-1972; and ANSI Z53.1-1971 safety color code for marking physical hazards. These ANSI standards were revised in 1991 as Z535.1-535.4. Warnings are primarily visual but can also be auditory, as in the case of a fire alarm. Warnings use sensory techniques that capture the attention of the employee. For instance, the use of the color red has a cultural identification with danger. The use of loud, discontinuous noise is culturally associated with emergency situations and can serve as a warning. After catching attention, the warning must provide information about the nature of the hazard. What is the hazard and what will it do to you? This provides the employee with an opportunity to assess the risk of ignoring the warning. Finally, the warning should provide some information about specific actions to take to avoid the hazard, such as ‘‘Stay clear of the boom’’ or ‘‘Stand back 50 feet from the crane’’ or ‘‘Stay away from this area.’’

Developing good warnings requires following the ANSI standards, using the results of current scientific studies and good judgment. Lehto and Miller (1986) wrote a book on warnings, and Lehto and Papastavrou (1993) define critical issues in the use and application of warnings. Laughery and Wogalter (1997) define the human factors aspects of warnings and risk perception and considerations for designing warnings. Peters (1997) discusses the critical aspects of technical communications that need to be considered from both human factors and legal perspectives. Considerations such as the level of employee’s word comprehension, the placement of the warning, environmental distortions, wording of instructions, and employee sensory overload, just to name a few, must be taken into account for proper warning design and use. Even when good warnings are designed, their ability to influence employee behavior varies widely. Even so, the regulations require their use and they do provide the employee an opportunity to make a choice. Warnings should never be used in place of engineering controls. Warnings always serve as an adjunct to other means of hazard control.

Instructions provide direction to employees that will help them to avoid or deal more effectively with hazards. They are the behavioral model that can be followed to ensure safety. The basis of good instructions is the job analysis, which provides detailed information on the job tasks, environment, tools, and materials used. The job analysis will identify high-risk situations. Based on verification of the information in the job analysis, a set of instructions on how to avoid hazardous situations can be developed. The implementation of such instructions as employee behavior will be covered in the next section under training and safe behavior improvement.

9.2.2. Promoting Safe and Healthful Behavior

There are four basic human factors approaches that can be used in concert to influence employee behavior to control workplace hazards:

1. Applying methods of workplace and job design to provide working situations that capitalize on worker skills
2. Designing organizational structures that encourage healthy and safe working behavior
3. Training workers in the recognition of hazards and proper work behavior(s) for dealing with these hazards
4. Improving worker health and safety behavior through work practices improvement

Each of these approaches is based on certain principles that can enhance effective safety performance.

9.2.3. Workplace and Job Design

The sensory environment in which job tasks are carried out influences worker perceptual capabilities to detect hazards and respond to them. Being able to see or smell a hazard is an important prerequisite in dealing with it; therefore, workplaces have to provide a proper workplace sensory environment for hazard detection. This means proper illumination and noise control and adequate ventilation.

There is some evidence that appropriate illumination levels can produce significant reductions in accident rate (McCormick 1976). The environment can influence a worker’s ability to perceive visual and auditory warnings such as signs or signals. To ensure the effectiveness of warnings, they should be highlighted. For visual signals, use the colors defined in the ANSI standard (Z535.1, ANSI 1991) and heightened brightness. For auditory signals, use changes in loudness, frequency, pitch, and phasing.

Work environments that are typically very loud and do not afford normal conversation can limit the extent of information exchange and may even increase the risk of occupational injury (Barreto et al. 1997). In such environments, visual signs are a preferred method for providing safety information. However, in most situations of extreme danger, an auditory warning signal is preferred because it attracts attention more quickly and thus provides for a quicker worker response. In general, warning signals should quickly attract attention, be easy to interpret, and provide information about the nature of the hazard.

Proper machinery layout, use, and design should be a part of good safety. Work areas should be designed to allow for traffic flow in a structured manner in terms of the type of traffic, the volume of traffic, and the direction of flow. The traffic flow process should support the natural progression of product manufacture and/or assembly. This should eliminate unnecessary traffic and minimize the complexity and volume of traffic. There should be clearly delineated paths for traffic to use and signs giving directions on appropriate traffic patterns and flow.

Work areas should be designed to provide workers with room to move about in performing tasks without having to assume awkward postures or come into inadvertent contact with machinery. Task-analysis procedures can determine the most economical and safest product-movement patterns and should serve as the primary basis for determining layout of machinery, work areas, traffic flow, and storage for each workstation.

Equipment must conform to principles of proper engineering design so that the controls that activate the machine, the displays that provide feedback of machine action, and the safeguards to protect workers from the action of the machine are compliant with worker skills and expectations. The action of the machine must be compliant with the action of the controls in temporal, spatial, and force characteristics.

The layout of controls on a machine is very important for proper machinery operation, especially in an emergency. In general, controls can be arranged on the basis of (1) their sequence of use, (2) common functions, (3) frequency of use, and (4) relative importance. Any arrangement should take into consideration (1) the ease of access, (2) the ease of discrimination, and (3) safety considerations such as accidental activation. The use of a sequence arrangement of controls is often preferred because it ensures smooth, continuous movements throughout the work operation. Generally, to enhance spatial compliance, the pattern of use of controls should sequence from left to right and from top to bottom. Sometimes controls are more effective when they are grouped by common functions. Often controls are clustered by common functions that can be used in sequence so that a combination of approaches is used.

To prevent unintentional activation of controls, the following steps can be taken: (1) recess the control, (2) isolate the control to an area on the control panel where it will be hard to trip unintentionally, (3) provide protective coverings over the control, (4) provide lock-out of the control so that it cannot be tripped unless unlocked, (5) increase the force necessary to trip the control so that extra effort is necessary and/or (6) require a specific sequence of control actions such that one unintentional action does not activate the machinery.

A major deficiency in machinery design is the lack of adequate feedback to the machine operator about the machine action, especially at the point of operation. Such feedback is often difficult to provide because there typically are no sensors at the point of operation (or other areas) to determine when such action has taken place. However, an operator should have some information about the results of the actuation of controls to be able to perform effectively. Operators may commit unsafe behaviors to gain some feedback about the machine's performance as the machine is operating that may put them in contact with the point of operation. To avoid this, machinery design should include feedback of operation. The more closely this feedback reflects the timing and action of the machinery, the greater the amount of control that can be exercised by the operator. The feedback should be displayed in a convenient location for the operator at a distance that allows for easy readability.

Work task design is a consideration for controlling safety hazards. Tasks that cause employees to become fatigued or stressed can contribute to exposures and accidents. Task design has to be based on considerations that will enhance employer attention and motivation. Thus, work tasks should be meaningful in terms of the breadth of content of the work that will eliminate boredom and enhance the employee's mental state. Work tasks should be under the control of the employees, and machine-paced operations should be avoided. Tasks should not be repetitious. This last requirement is sometimes hard to achieve. When work tasks have to be repeated often, providing the employee with some control over the pacing of the task reduces stress associated with such repetition. Because boredom is also a consideration in repetitious tasks, employee attention can be enhanced by providing frequent breaks from the repetitious activity to do alternative tasks or take a rest. Alternative tasks enlarge the job and enhance the breadth of work content and employee skills.

The question of the most appropriate work schedule is a difficult matter. There is evidence that rotating-shift systems produce more occupational injuries than fixed-shift schedules (Smith et al. 1982). This implies that fixed schedules are more advantageous for injury control. However, for many younger workers (without seniority and thus often relegated to afternoon and night shifts) this may produce psychosocial problems related to family responsibilities and entertainment needs, and therefore lead to stress. Because stress can increase illness and injury potential, the gain from the fixed-shift systems may be negated by stress. This suggests that one fruitful approach may be to go to fixed shifts with volunteers working the nonday schedules. Such an approach provides enhanced biological conditions and fewer psychosocial problems.

Overtime work should be avoided because of fatigue and stress considerations. It is preferable to have a second shift of workers than to overtax the physical and psychological capabilities of employees. Since a second shift may not be economically feasible, some considerations need to be given for determining appropriate amounts of overtime. This is a judgmental determination since there is inadequate research evidence on which to base a definitive answer. It is reasonable that job tasks that create high levels of physical fatigue and/or psychological stress should not be performed more than 10 hours in one day and 50 hours in one week. Jobs that are less fatiguing and stressful can probably be safely performed for up to 12 hours per day. There is some evidence that working more than 50 hours per week can increase the risk of coronary heart disease (Breslow and Buell 1960; Russek and Zohman 1958), and therefore working beyond 50 hours per week for extended periods should be avoided.

9.3. Organizational Design

Organizational policies and practices can have a profound influence on a company's health and safety record and the safety performance of its employees. To promote health and safety, organizational policies and practices should demonstrate that safety is an important organizational objective. The first step in this process is to establish a written organizational policy statement on health and safety. This should be followed up with written procedures to implement the policy. Such a formalized structure is the foundation on which all health and safety activities in the company are built. It provides the legitimate basis for undertaking health- and safety-related actions and curtails the frequent arguments among various levels of management about what constitutes acceptable activities. Such a policy statement also alerts employees to the importance of health and safety.

For employees, the policy statement is the declaration of an intent to achieve a goal. However, employees are skeptical of bureaucratic policies and look for more solid evidence of management commitment. Thus, the timing and sequence of health- and safety-related decisions demonstrate how the policy will be implemented and the importance of health and safety considerations. A health and safety policy with no follow-through is worthless and in fact may be damaging to employee morale by showing employees a lack of management commitment. This can backfire and can lead to poor employee safety attitudes and behaviors. Thus, an employer has to put the ''money where the mouth is'' to demonstrate commitment. If not, a policy is an empty promise.

Since physical conditions are the most obvious health and safety hazards, it is important that they be dealt with quickly to demonstrate management commitment. Relations with local, state, and federal health and safety agencies reflect on management commitment to health and safety. Companies that have written safety policies and guidelines with adequate follow-through but are constantly at odds with government health and safety officials are sending a confusing message to their employees. It is important to have a good public image and good public relations with government agencies, even through there may be specific instances of disagreement and even hostility. This positive public image will enhance employee attitudes and send a consistent message to employees about the importance of health and safety.

In this regard, organizations must ensure an adequate flow of information in the organization. The flow must be bidirectional, that is, upward as well as downward. One approach for dealing with safety communications is to establish communication networks. These are formal structures to ensure that information gets to the people who need to know the message(s) in a timely way. These networks are designed to control the amount of information flow to guard against information overload, misinformation, or a lack of needed information. Such networks have to be tailored to the specific needs of an organization. They are vital for hazard awareness and general health and safety information. For instance, in a multishift plant, information on a critical hazardous condition can be passed from shift to shift so that workers can be alerted to the hazard. Without a communication network, this vital information may not get to all affected employees and an avoidable exposure or accident could occur.

Organizational decision making is an important motivational tool for enhancing employee health and safety performance. Decisions about work task organization, work methods, and assignments should be delegated to the lowest level in the organization at which they can be logically made; that is, they should be made at the point of action. This approach has a number of benefits. For example, this level in the organization has the greatest knowledge of the work processes and operations and of their associated hazards. Such knowledge can lead to better decisions about hazard control. Diverse input to decision making from lower levels up to higher levels makes for better decisions as there are more options to work with. Additionally, this spreading of responsibility by having people participate in the inputs to decision making promotes employee and line supervisor consideration of safety and health issues. Such participation has been shown to be a motivator and to enhance job satisfaction (French 1963; Korunka et al. 1993; Lawler 1986). It also gives employees greater control over their work tasks and a greater acceptance of the decisions concerning hazard control due to the shared responsibility. All of this leads to decreased stress and increased compliance with safe behavior(s).

Organizations have an obligation to increase company health and safety by using modern personnel practices. These include appropriate selection and placement approaches, skills training, promotion practices, compensation packages, and employee-assistance programs. For safety purposes, the matching of employee skills and needs to job task requirements is an important consideration. It is inappropriate to place employees at job tasks for which they lack the proper skills or capacity. This will increase illness and injury risk and job stress. Selection procedures must be established to obtain a properly skilled workforce. When a skilled worker is not available, training must be undertaken to increase skill levels to the proper level before a task is undertaken. This assumes that the employer has carried out a job task analysis and knows the job skills that are required. It also assumes that the employer has devised a way to test for the required skills. Once these two conditions have been met, the employer can improve the fit between employee skills and job task requirements through proper selection, placement, and training. Many union contracts require that employees with seniority be given first consideration for promotions. Such consideration is in keeping with this approach as long as the worker has the appropriate skills to do the job task or the aptitude to be trained to attain the necessary skills. If a person does not have the necessary knowledge and skills or cannot be adequately trained, there is good reason to exclude that individual from a job regardless of seniority.

9.3.1. Safety Training

Training workers to improve their skills and recognize hazardous conditions is a primary means for reducing exposures and accidents. Cohen and Colligan (1998) found that safety and health training was effective in reducing employee risk. Training can be defined as a systematic acquisition of knowledge, concepts, or skills that can lead to improved performance or behavior. Eckstrand (1964) defined seven basic steps in training: (1) defining the training objectives, (2) developing criteria measures for evaluating the training process and outcomes, (3) developing or deriving the content and materials to be learned, (4) designing the techniques to be used to teach the content, (5) integrating the learners and the training program to achieve learning, (6) evaluating the extent of learning, and (7) modifying the training process to improve learner comprehension and retention of the content. These steps provide the foundation for the application of basic guidelines that can be used for designing the training content, and integrating the content and the learner.

In defining training objectives, two levels can be established: global and specific. The global objectives are the end goals that are to be met by the training program. For instance, a global objective might be the reduction of eye injuries by 50%. The specific objectives are those that are particular to each segment of the training program, including the achievements to be reached by the completion of each segment. A specific objective might be the ability to recognize eye-injury hazards by all employees by the end of the hazard-education segment. A basis for defining training objectives is the assessment of company safety problem areas. This can be done using hazard-identification methods such as injury statistics, inspections, and hazard surveys. Problems should be identified, ranked in importance, and then used to define objectives.

To determine the success of the training process, criteria for evaluation need to be established. Hazard-identification measures can be used to determine overall effectiveness. Thus, global objectives can be verified by determining a reduction in injury incidence (such as eye injuries) or the elimination of a substantial number of eye hazards. However, it is necessary to have more sensitive measures of evaluation that can be used during the course of training to assess the effectiveness of specific aspects of the training program. This helps to determine the need to redirect specific training segments if they prove to be ineffective. Specific objectives can be examined through the use of evaluation tools. For instance, to evaluate the ability of workers to recognize eye hazards, a written or oral examination can be used. Hazards that are not recognized can be emphasized in subsequent training and retraining.

The content of the training program should be developed based on the learners' knowledge level, current skills, and aptitudes. The training content should be flexible enough to allow for individual differences in aptitudes, skills, and knowledge, as well as for individualized rates of learning. The training content should allow all learners to achieve a minimally acceptable level of health and safety knowledge and competence by the end of training. The specifics of the content deal with the skills to be learned and the hazards to be recognized and controlled.

There are various techniques that can be used to train workers. Traditionally, on-the-job training (OJT) has been emphasized to teach workers job skills and health and safety considerations. The effectiveness of such training will be influenced by the skill of the supervisor or lead worker in imparting knowledge and technique as well as his or her motivation to successfully train the worker. First-line supervisors and lead workers are not educated to be trainers and may lack the skills and motivation to do the best job. Therefore, OJT has not always been successful as the sole safety training method. Since the purpose of a safety training program is to impart knowledge and teach skills, it is important to provide both classroom experiences to gain knowledge and OJT to attain skills.

Classroom training is used to teach concepts and improve knowledge and should be carried out in small groups (not to exceed 15 employees). A small group allows for the type of instructor–student interaction needed to monitor class progress, provide proper motivation and determine each learner's comprehension level. Classroom training should be given in an area free of distractions to allow learners to concentrate on the subject matter. Training sessions should not exceed 30 minutes, after which workers can return to their regular duties. There should be liberal use of visual aids to increase comprehension and make the training more concrete and identifiable to the learners. In addition, written materials should be provided that can be taken from the training session for study or reference away from the classroom.

For OJT the major emphasis should be on enhancing skills through observation and practice. Key workers with exceptional skills can be used as role models and mentors. Learners can observe these key workers and pick up tips from them. They then can practice what they have learned under the direction of the key workers to increase their skill, obtain feedback on their technique, and be motivated to improve.

Once the learner and the training program have been integrated, it will be necessary to evaluate the extent of learning. This can be done by testing learner knowledge and skills. Such testing should be done frequently throughout the training process to provide the learners with performance feedback and allow for program redirection as needed. Knowledge is best tested by written examinations that test acquisition of facts and concepts. Pictorial examinations (using pictures or slides of working conditions) can be used to determine hazard recognition ability. Oral questioning on a frequent basis can provide the instructor with feedback on the class comprehension of materials being presented, but should not be used for individual learner evaluation, since some learners may not be highly verbal and could be demotivated by being asked to recite. Skills testing should take place in the work area under conditions that control hazard exposures. Skills can be observed during practice sessions to determine progress under low-stress conditions.

The final stage in a training program, the success of the program having been determined, is to make modifications to improve the learning process. Such modifications should be done on a continuous basis as feedback on learner performance is acquired. In addition, at the end of the program it is necessary to determine whether the company objectives have been met. If so, should the objectives be modified? The answers to these questions can lead to modifications in the training program.

9.3.2. Hazard Reduction through Improved Work Practices

A large number of the hazards in the workplace are produced by the interaction between employees and their tools and environment. These hazards cannot be completely controlled through hazard inspection and machine guarding. They can be controlled by increasing employee recognition of the hazards and by proper worker behavior. Such behavior may be an evasive action when a hazard occurs, or it may be the use of safe work procedures to ensure that hazards will not occur. There are very few hazard-control efforts that are not in some way dependent on employee behavior. Making employees aware of hazards is meaningless if they do not choose to do something about them. For example, when controlling chemical exposures, personal protective equipment is useless if it is not worn. Likewise, an inspection system is useless if hazards are not reported or not corrected when reported. Thus, taking positive action (behavior) is central to hazard control. It is often true that there are no ideal engineering control methods to deal with a certain hazard. In such a case, it is usually necessary to use proper work practices to avoid hazardous exposure when engineering controls are not feasible. Likewise, even when engineering control will work successfully it is necessary to have employees use good work practices to get the engineering controls to work properly.

Conard (1983) has defined work practices as employee behaviors that can be simple or complex and that are related to reducing a hazardous situation in occupational activities. A series of steps can be used in developing and implementing work practices for eliminating occupational hazards:

1. The definition of hazardous work practices
2. The definition of new work practices to reduce the hazards
3. Training employees in the desired work practices
4. Testing the new work practices in the job setting
5. Installing the new work practices using motivators
6. Monitoring the effectiveness of the new work practices
7. Redefining the new work practices
8. Maintaining proper employee habits regarding work practices

In defining hazardous work practices, there are a number of sources of information that should be examined. Injury and accident reports such as the OSHA 301 Form provide information about the circumstances surrounding an injury. Often employee or management behaviors that contributed to the injury can be identified. Employees are a good source of information about workplace hazards. They can be asked to identify critical behaviors that may be important as hazard sources or hazard controls. First-line supervisors are also a good source of information because they are constantly observing employee behavior. All of these sources should be examined; however, the most important source of information is in directly observing employees at work.

There are a number of considerations when observing employee work behaviors. First, observation must be an organized proposition. Before undertaking observations, it is useful to interview employees and first-line supervisors and examine injury records to develop a checklist of significant behaviors to be observed. This should include hazardous behaviors as well as those that are used to enhance engineering control or directly control hazards. The checklist should identify the job task being observed, the types of behaviors being examined, their frequency of occurrence, and a time frame of their occurrence. The observations should be made at random times so that employees do not change their natural modes of behavior when observed. The time of observation should be long enough for a complete cycle of behaviors associated with a work task(s) of interest to be examined. Two or three repetitions of this cycle should be examined to determine consistency in behavior with an employee and among employees. Random times of recording behavior are most effective in obtaining accurate indications of typical behavior. The recorded behaviors can be analyzed by the frequency and pattern of their occurrence as well as their significance for hazard control. Hot spots can be identified. All behaviors need to be grouped into categories in regard to hazard control efforts and then prioritized.

The next step is to define the proper work practices that need to be instilled to control the hazardous procedures observed. Sometimes the observations provide the basis for the good procedures that you want to implement. Often, however, new procedures need to be developed. There are four classes of work practices that should be considered: (1) hazard recognition and reporting, (2) housekeeping, (3) doing work tasks safely, and (4) emergency procedures. The recognition of workplace hazards requires that the employee be cognizant of hazardous conditions through training and education and that employees actively watch for these conditions. Knowledge is useless unless it is applied. These work practices ensure the application of knowledge and the reporting of observed hazards to fellow workers and supervisors. Housekeeping is a significant consideration for two reasons. A clean working environment makes it easier to observe hazards. It is also a more motivating situation that enhances the use of other work practices.

The most critical set of work practices deals with carrying out work tasks safely through correct skill use and hazard-avoidance behaviors. This is where the action is between the employee and the environment, and it must receive emphasis in instilling proper work practices. Situations occur that are extremely hazardous and require the employee to get out of the work area or stay clear of the work area. These work practices are often life-saving procedures that need special consideration because they are used only under highly stressful conditions, such as emergencies.

Each of these areas needs to have work practices spelled out. These should be statements of the desired behaviors specified in concise, easily understandable language. Statements should typically be one sentence long and should never exceed three sentences. Details should be excluded unless they are critical to the proper application of the work practice. The desired work practices having been specified, employees should be given classroom and on-the-job training to teach them the work practices. Training approaches discussed earlier should be applied. This includes classroom training as well as an opportunity for employees to test the work practices in the work setting.

To ensure the sustained use of the learned work practices, it is important to motivate workers through the use of incentives. There are many types of incentives, including money, tokens, privileges, social rewards, recognition, feedback, participation, and any other factors that motivate employees, such as enriched job tasks. Positive incentives should be used to develop consistent work practice patterns.

Research has demonstrated that the use of financial rewards in the form of increased hourly wage can have a beneficial effect on employee safety behaviors and reduced hazard exposure. One study (Smith et al. 1983; Hopkins et al. 1986) evaluated the use of behavioral approaches for promoting employee use of safe work practices to reduce their exposure to styrene. The study was conducted in three plants and had three components: (1) the development and validation of safe work practices for working with styrene in reinforced fiberglass operations, (2) the development and implementation of an employee training program for learning the safe work practices, and (3) the development and testing of a motivational technique for enhancing continued employee use of the safe work practices. Forty-three work practices were extracted from information obtained from a literature search, walk-through plant survey, interviews with employees and plant managers, and input from recognized experts in industrial safety and hygiene. The work practices were pilot tested for their efficacy in reducing styrene exposures. A majority of the work practices were found to be ineffective in reducing styrene exposures, and only those that were effective were incorporated into a worker training program.

The worker training program consisted of classroom instruction followed up with on-the-job application of the material learned in class. Nine videotapes were made to demonstrate the use of safe work practices. Basic information about each work practice and its usefulness was presented, followed by a demonstration of how to perform the work practice. Employees observed one videotape for 15 minutes per week for nine weeks. After each showing, a discussion session was held, followed up by on-the-job application of the work practice given by the research training instructor. Once training was completed, each employee was included in the motivational program. This program was based on a financial reward of $10 per week for using the safe work practices. Observations of employee behavior were made by researchers four times daily on a random basis. These observations served as the basis for an employee's receipt of the financial reward.

The effectiveness of the training and motivational programs was measured by examining the changes in employee behavior from before the programs to the end of the study. Approximately 35% of the safe work practices were observed prior to training for the 41 employees studied in the three plants. At the end of the study, approximately 95% of the safe work practices were observed. The real significance of this increased use of safe work practices lies in the effectiveness in reducing employee exposures to styrene. The results indicated a reduction in styrene exposure from before training to the end of the study of 36%, 80%, and 65% for each plant respectively. In a follow-up evaluation a few years after the behavioral management program was discontinued, it was found that approximately 90% of the safe work practices were still being used by the employees even in the absence of rewards. The study results demonstrated the effectiveness of behavioral techniques for increasing worker use of safe work practices, as well as the effectiveness of such usage in reducing employee exposures to workplace hazards.

10. SAFETY PROGRAMS

The preceding materials provide the basis for developing an effective company hazard-control program. However, there are a number of other elements to consider in developing a safety program or upgrading your current program. These include organizational policies, managing various elements of the program, motivational practices, hazard-control procedures, dealing with employees, accident investigations, and injury recording. Aspects of each of these have already been discussed, and in this section they are integrated into an effective safety program. There has been considerable research into the necessary elements for a successful safety program (see Cohen 1977; Smith et al. 1978; Cleveland et al. 1979; Zimolong 1997) and how these elements should be applied. One primary factor emerges from every study on this subject. A safety program will not be successful unless there is a commitment to the program by top management. This dictates that there be a written organizational policy statement on the importance of safety and the general procedures the corporation intends to use to meet this policy. Having such a policy is just the first step toward effective management commitment.

Smith et al. (1978) have shown that it takes more than a written policy to ensure successful safety performance. It takes involvement on the part of all levels of management in the safety program. From the top managers it means that they must get out onto the shop floor often and talk to employees about plant conditions and safety problems. This can be on a scheduled basis, but it seems to be more effective on an informal basis. For middle managers there is a need to participate in safety program activities such as monthly hazard awareness meetings or weekly toolbox meetings. This does not necessitate active presentations by these managers, but it does mean active participation in group discussions and answering worker questions. These activities bring the upper and middle managers in touch with potential hazard sources and educates them to shop floor problems. It also demonstrates to employees that management cares about their safety and health.

Another aspect of management commitment is the level of resources that are made available for safety programming. Cohen (1977), in reviewing successful program research, found that organizational investment in full-time safety staff was a key feature to good plant safety performance. The effectiveness of safety and health staff was greater the higher they were in the management structure. The National Safety Council (1974) has suggested that plants with less than 500 employees and a low to moderate hazard level can have an effective program with a part-time safety professional. Larger plants or those with more hazards need more safety staff.

Along with funds for staffing, successful programs also make funds available for hazard abatement in a timely fashion. Thus, segregated funds are budgeted to be drawn upon when needed. This gives the safety program flexibility in meeting emergencies when funds may be hard to get quickly from operating departments. An interesting fact about companies with successful safety programs is that they are typically efficient in their resource utilization, planning, budgeting, quality control, and other aspects of general operations and include safety programming and budgeting as just another component of their overall management program. They do not single safety out or make it special; instead, they integrate it into their operations to make it a natural part of daily work activities.

Organizational motivational practices will influence employee safety behavior. Research has demonstrated that organizations that exercise humanistic management approaches have better safety performance (Cohen 1977; Smith et al. 1978; Cleveland et al. 1979). These approaches are sensitive to employee needs and thus encourage employee involvement. Such involvement leads to greater awareness and higher motivation levels conducive to proper employee behavior. Organizations that use punitive motivational techniques for influencing safety behavior have poorer safety records than those using positive approaches. An important motivational factor is encouraging communication between various levels of the organization (employees, supervisors, managers). Such communication increases participation in safety and builds employee and management commitment to safety goals and objectives. Often informal communication is a more potent motivator and provides more meaningful information for hazard control.

An interesting research finding is that general promotional programs aimed at enhancing employee awareness and motivation, such as annual safety awards dinners and annual safety contests, are not very effective in influencing worker behavior or company safety performance (Smith et al. 1978). The major reason is that their relationship in time and subject matter (content) to actual plant hazards and safety considerations is so abstract that workers cannot translate the rewards to specific actions that need to be taken. It is hard to explain why these programs are so popular in industry despite being so ineffective. Their major selling points are that they are easy to implement and highly visible, whereas more meaningful approaches take more effort.

Another important consideration in employee motivation and improved safety behavior is training. Two general types of safety training are of central importance: skills training and training in hazard awareness. Training is a key component to any safety program because it is important to employee knowledge of workplace hazards and proper work practices and provides the skills necessary to use the knowledge and the work practices. Both formal and informal training seem to be effective in enhancing employee safety performance (Cohen and Colligan 1998). Formal training programs provide the knowledge and skills for safe work practices, while informal training by first-line supervisors and fellow employees maintains and sharpens learned skills.

All safety programs should have a formalized approach to hazard control. This often includes an inspection system to define workplace hazards, accident investigations, record keeping, a preventive maintenance program, a machine guarding program, review of new purchases to ensure compliance with safety guidelines, and housekeeping requirements. All contribute to a safety climate that demonstrates to workers that safety is important. However, the effectiveness of specific aspects of such a formalized hazard-control approach have been questioned (Cohen 1977; Smith et al. 1978). For instance, formalized inspection programs have been shown to deal with only a small percentage of workplace hazards (Smith et al. 1971). In fact, Cohen (1977) indicated that more frequent informal inspections may be more effective than more formalized approaches. However, the significance of formalized hazard-control programs is that they establish the groundwork for other programs such as work practice improvement and training. In essence, they are the foundation for other safety approaches. They are also a source of positive motivation by demonstrating management interest in employees by providing a clean workplace free of physical hazards. Smith et al. (1978) have demonstrated that sound environmental conditions are a significant contribution to company safety performance and employee motivation.

11. PARTICIPATIVE APPROACHES TO RESPOND TO THE EMERGING HAZARDS OF NEW TECHNOLOGIES

Hazard control for new technologies requires a process that will be dynamic enough to be able to deal with the increasing rate of hazards caused by technological change. Research on successful safety program performance in plants with high hazard potential has shown a number of factors that contribute to success (Cohen 1977; Smith et al. 1978). These are having a formal, structured program so people know where to go for help, management commitment and involvement in the program, good communications between supervisors and workers, and worker involvement in the safety and health activities. These considerations are important because they provide a framework for cooperation between management and employees in identifying and controlling hazards. These factors parallel the basic underlying principles of quality management, social democracy, hazard surveys, ergonomic committees, and other employee-involvement approaches that will be discussed below—that is, developing management and employee cooperation, participation, and honest exchange of ideas about problems in a controlled format.

11.1. Quality Improvement

The development of total quality management (TQM) approaches may produce some positive results with regard to occupational safety and health (Zink 1999). Power and Fallon (1999) have proposed TQM as a framework for integration of health and safety activities with other functions. They argue that the practice of safety management should include the following TQM principles: management commitment to occupational safety and health objectives, plans and policies; development of a health and safety culture; employee involvement in safety activities, such as risk assessment and training of new employees; measurement and monitoring of health and safety performance; and continuous improvement. Smith (1999) has proposed a model for integrating ergonomics, safety, and quality based on behavioral cybernetics. From a behavioral cybernetics perspective, participatory ergonomics and safety and quality management are effective because they enable workers to control sensory feedback from job-related decisions or working conditions that affect them and in turn to generate sensory feedback for the control and benefit of other workers. Worker involvement in decision making, worker control over the production process, and job enrichment enhance the overall level of worker self-control. Use of workers as resource specialists and emphasis on skill development can benefit the integration of ergonomics, safety management, and quality management of the organization.

11.2. International Organization for Standardization

The International Organization for Standardization (ISO) has been developing technical standards over many sectors of business, industry, and technology since 1947. With the exception of ISO 9000 and ISO 14000, the vast majority of ISO standards are highly specific. They are documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics. The goal of these standards is to ensure that materials, products, processes, and services are fit for their purpose. Then in 1987 came ISO 9000, followed nearly 10 years later by ISO 14000. These two standards are very different from the majority of ISO's highly specific standards.

ISO 9000 and ISO 14000 are known as generic management system standards. Management system standards provide the organization with a model to follow in setting up and operating the management system. ISO 9000 is concerned with quality management, whereas ISO 14000 is concerned with environmental management. Quality management regards what the organization does to ensure that its products conform to the customer's requirements. Environmental management regards what the organization does to minimize harmful effects on the environment caused by its activities. Both ISO 9000 and ISO 14000 concern the way an organization goes about its work, and not directly the result of this work. That is, ISO 9000 and ISO 14000 concern processes, and not products, at least directly. Both standards provide requirements for what the organization must do to manage processes influencing quality (ISO 9000) or the processes influencing the impact on the environment (ISO 14000).

The ISO 9000 family of standards currently contains over 20 standards and documents. By the end of the year 2000, a new version of the ISO 9000 quality management standards was issued. The three primary standards in the Year 2000 ISO 9000 are:

- ISO 9000: Quality management systems—Fundamentals and vocabulary
- ISO 9001: Quality management systems—Requirements
- ISO 9004: Quality management systems—Guidance for performance improvement.

The new ISO 9000 family of quality management standards is being developed to achieve a coherent terminology with the ISO 14000 family and other management standards, including possibly an OSH management standard.

In 1996, the ISO held an international conference in Geneva to test stakeholder views on developing a standard on occupational health and safety. Given the limited support from the main stakeholders for the ISO to develop international standards in this field, ISO decided that no further action should be taken. Recently, the ISO has reopened the issue of whether to develop management system standards to help organizations meet their responsibilities. The British Standards Institution (BSI) has submitted a proposal to the ISO for creation of a new ISO technical committee on OHS management standards. The BSI has proposed to transform BS 8800, the British "noncertifiable" OHS management system guidelines, into an ISO standard. The ISO is looking into the issue of whether or not to develop an occupational health and safety management standard.

Many companies have invested considerable resources in order to obtain certification of their quality management systems according to the ISO 9000 standards. From a safety point of view, one may wonder whether the implementation of ISO 9000 management systems can encourage the development of safer and healthier work environments. In Sweden, Karltun et al. (1998) examined the influences on working conditions, following the implementation of ISO 9000 quality systems in six small and medium-sized companies. Improvements to the physical work environment triggered by the ISO implementation process were very few. There were improvements in housekeeping and production methods. Other positive aspects present in some of the companies included job enrichment and a better of understanding of employees' role and importance to production. However, the implementation of ISO 9000 was accompanied by increased physical strain, stress, and feelings of lower appreciation. According to Karltun and his colleagues (1998), improved working conditions could be triggered by the implementation of ISO quality management standards if additional goals, such as improved working conditions, are considered by top management and if a participative implementation process is used. Others have argued that quality management systems and environmental management systems can be designed to address occupational health and safety (Wettberg 1999;

Martin 1999). A study by Eklund (1995) showed a relationship between ergonomics and quality in assembly work. Tasks that had ergonomic problems (e.g., physical and psychological demands) were also the tasks that had quality deficiencies. The evidence for the integration between quality management and occupational safety and health is weak. However, there is reason to believe that improved health and safety can be achieved in the context of the implementation of ISO 9000 management standards.

11.3. Social Democracy

One framework for addressing the health and safety issues of new technology is the social democratic approach practiced in Norway and Sweden (Emery and Thorsrud 1969; Gardell 1977). This approach is based on the concept that workers have a right to participate in decisions about their working conditions and how their jobs are undertaken. In Sweden, there are two central federal laws that establish the background for health and safety. One, similar to U.S. Occupational Safety and Health Act, established agencies to develop and enforce standards as well as to conduct research. The second is the Law of Codetermination, which legislates the right of worker representatives to participate in decision making on all aspects of work. This law is effective because over 90% of the Swedish blue- and white-collar workforce belong to a labor union and the unions take the lead in representing the interests of the employees in matters pertaining to working conditions, including health and safety. The Scandinavian approach puts more emphasis on the quality of working life in achieving worker health and well being. Thus, there is emphasis on ensuring that job design and technology implementation do not produce physical and psychological stress. This produces discussion and action when safety and health problems are first reported.

11.4. Hazard Survey

Organizational and job-design experts have long proposed that employee involvement in work enhances motivation and produces production and product quality benefits (Lawler 1986). Smith and Beringer (1986) and Zimolong (1997) have recommended that employees be involved in safety programming and hazard recognition to promote safety motivation and awareness. An effective example of using this concept in health and safety is the hazard survey program (Smith 1973; Smith and Beringer 1986). Smith et al. (1971) showed that most occupational hazards were either transient or due to improper organizational or individual behavior. Such hazards are not likely to be observed during formal inspections by safety staff or compliance inspections by state or federal inspectors. The theory proposes that the way to keep on top of these transient and behavioral hazards is to have them identified on a continuous basis by the employees as they occur through employee participation.

One approach that gets employee involvement is the hazard survey. While inspection and illness/injury analysis systems can be expected to uncover a number of workplace hazards, they cannot define all of the hazards. Many hazards are dynamic and occur only infrequently. Thus, they may not be seen during an inspection or may not be reported as a causal factor in an illness or injury. To deal with hazards that involve dynamically changing working conditions and/or worker behaviors requires a continuously operating hazard-identification system. The hazard survey is a cooperative program between employees and managers to identify and control hazards. Since the employee is in direct contact with hazards on a daily basis, it is logical to use employees' knowledge of hazards in their identification. The information gathered from employees can serve as the basis of a continuous hazard identification system that can be used by management to control dynamic workplace hazards.

A central concept of this approach is that hazards exist in many forms as fixed physical conditions, as changing physical conditions, as worker behaviors, and as an operational interaction that causes a mismatch between worker behavior and physical conditions (Smith 1973). This concept defines worker behavior as a critical component in the recognition and control of all of these hazards. Involving workers in hazard recognition sensitizes them to their work environment and acts as a motivator to use safe work behaviors. Such behaviors include using safe work procedures to reduce hazard potential, using compensatory behaviors when exposed to a known hazard, or using avoidance behaviors to keep away from known hazards. The hazard survey program also establishes communication between supervisors and employees about hazards.

The first step in a hazard survey program is to formalize the lines of communication. A primary purpose of this communication network is to get critical hazard information to decision makers as quickly as possible so that action can be taken to avert an exposure or accident. Traditional communication routes in most companies do not allow for quick communication between workers and decision makers, and thus serious hazards may not be corrected before an exposure or accident occurs. Each company has an established organizational structure that can be used to set up a formalized communication network. For instance, most companies are broken into departments or work units. These can serve as the primary segments within which workers report hazards. These hazards can be dealt with at the departmental level or communicated to higher-level decision makers for action.

Once primary communication units are established, a process to communicate hazard information has to be established. This requires structure and rules. The structure of the program should be simple so that information can flow quickly and accurately. It is important to designate a company decision maker who has the responsibility and authority to respond to serious hazards through the expenditure of company resources. Sometimes the hazards can be dealt with immediately at the departmental level by the supervisor. This is often true when large expenditures are not involved. Each department may decide to select someone in that department to serve as the primary communication source between the workers in the department and the supervisor. Hazards are reported directly to this person, who then reports them to the supervisor or, in the case of a serious hazard, immediately to the company decision maker.

It is best to have a formal procedure for recording employee-identified hazards. This can be easily accomplished by a hazard form that provides a written record of the hazard, its location, and other pertinent information, such as the number of employees exposed and possible hazard-control measures. These forms can be distributed to each employee and be available from the department committee member. Employees may wish to express their views about the existence of potential hazards anonymously on the forms. Employees should report near-miss accidents, property damage incidents, and potential injury-producing hazards. It is essential in a program such as this that employees be given anonymity if desired and that they be assured that no action will be taken against them for their participation (even if they report silly hazards).

Once hazards have been examined, rated, and ranked by the committee, some plan of action for their control should be developed either by the committee or by company management. The results of the hazards review by the committee and the action to be taken should be fed back to employees. Experience using this type of program indicates that for every 100 hazards reported, 1 is very serious, needing immediate action, 24 require attention quickly to avert a potential accident, 50 require some minor action to improve the quality of working conditions but do not concern a serious hazard, and 25 concern gripes and hassles of employees that are not related to safety hazards.

Employees are expected to fulfill the following duties in this program:

1. Examine the workplace to determine whether there are hazards
2. Report hazards on the form and return it to the department committee member or supervisor
3. Make an effort to find out what has happened to the hazard(s) reported
4. Continue to report hazards as they are observed

This program will provide continuous monitoring of safety hazards using employee input. This participation should stimulate employee awareness of safety and motivate the employees to work more safely. The continued use of the program should encourage the employees to have a vested interest in their safety and that of their fellow employees. This sense of involvement can carry over into improvement in individual work habits.

11.5. Employee/Management Ergonomics Committee

Another employee-involvement approach that could be successful in addressing some of the emerging issues of new technology is the joint union/management ergonomic committee (Hagglund 1981). This approach starts with a joint training course for union stewards and line managers about the hazards of chronic trauma and possible ergonomic interventions to resolve these problems. The course covers how to recognize ergonomic hazards, how to measure the hazard potential, and how to develop dialogue and cooperation between labor and management. This training is led by a facilitator (typically a university staff person), and is conducted at the company during work hours. Employees and supervisors are given time from their jobs to participate, which demonstrates the importance of the program. One main purpose of the training is to generate discussion between line managers/supervisors and union representatives about specific hazards and worker perceptions. This give and take develops an understanding of the other person's perspective and concerns. It often generates good solutions, especially toward the end of the course, when an understanding of the course technical material is integrated within the specific context of the plant.

After the training, an ergonomics committee composed of top management, select line management, and select union stewards is established that meets on a regular basis to discuss ergonomic problems and potential solutions. Employees with ergonomic problems can report them to a member of this committee, which typically tends to be a union steward. Semiannual retraining is given to the ergonomics committee on emerging issues that are generated by the kinds of problems being reported at the company. This approach has been extremely successful in reducing the extent of chronic trauma in electronic assembly plants in Wisconsin.

12. CONCLUSIONS

Designing for successful occupational health and safety performance requires a systematic approach. This includes understanding that the workplace is a system where changes in one element lead to influences on the other system components. It also means that efforts to make improvements must be multifaceted and address all of the elements of the work system. Health and safety improvements begin with an understanding of the hazards, the evaluation of injury and illness experience, the development of interventions, the implementation of improvements, follow-up to evaluate the results of improvements, and continuous efforts of evaluation and improvement. Good programming starts at the top of the company and includes all levels of the organizational structure. Employee input and involvement are critical for success. Often there is a need for technical expertise when dealing with complex or new hazards. In the end, having everyone in the company alert to health and safety issues should lead to improved health and safety performance.

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APPENDIX
Useful Web Information Sources

American Association of Occupational Health Nurses, http://www.aaohn.org
American Board of Industrial Hygiene, http://www.abih.org

American College of Occupational and Environmental Medicine, http://www.acoem.org
American Council of Government Industrial Hygienists, http://www.acgih.org
American Industrial Hygiene Association, http://www.aiha.org
American Psychological Association, http://www.apa.org
Bureau of Labor Statistics, http://www.bls.gov
Centers for Disease Control and Prevention, http://www.cdc.gov
Department of Justice, http://www.usdoj.gov
Department of Labor, http://www.dol.gov
National Institute for Environmental Health Sciences, http://www.niehs.gov
National Institute for Occupational Safety and Health, http://www.niosh.gov
National Safety Council, http://www.nsc.org
Occupational Safety and Health Administration, http://www.osha.gov