CHAPTER 1
THE SAFETY AND HEALTH MANAGER

Everyone wants a safe and healthful workplace, but what each person is willing to do to achieve this worthwhile objective can vary a great deal.

Management of each firm must decide at what level, along a broad spectrum, the safety and health effort will be aimed.... A continuum between personal freedom and individual responsibility.

It has been proven that the attitude of the worker is the most important determinant for his or her safety, but attitude alone cannot make a dangerous job safe.

The safety director or industrial hygienist, sets the tone of the safety and health program within a firm.

It was not unusual for a safety director's work to be typified by public relations activities, such as posting motivational signs and compiling statistics.

In the 1970’s the passage of the occupational safety and health act of 1970 created the occupational safety and health administration (OSHA), a federal agency whose regulations would have a large impact on the role of the typical safety director.

There is little doubt that OSHA enhanced the authority of the safety manager in the typical industrial plant in the United States. The field of occupational health has probably benefited more from OSHA than has the field of occupational safety.

This text will use the designation safety and health manager, recognizing the dual nature of the job.

The purpose of this book is to provide tools and guidelines to safety and health managers to help them execute their enlarged duties. Dealing with applicable standards is one of the greatest challenges facing today's safety and health manager.

10% of the standards generate 90% of the frequently cited standards and receive prime attention.

Safety and health managers need to know the "why" behind the standards.

A Reasonable Objective

In the real world we must choose between these three categories of hazards with respect to feasibility of correction:

1. Hazards that are physically infeasible to correct
2. Hazards that are physically feasible, but are economically infeasible to correct

3. Hazards that are economically and physically feasible to correct

This book does not really advocate elimination of all workplace hazards. Such a goal is unattainable, and to reach for it is poor strategy because it ignores the need for discriminating among hazards to be corrected.

Case Study 1.1 Page 3

By reacting to every hazard that happens to show up, the safety and health manager may be missing opportunities to have a really significant impact on worker safety and health.

Even the law does not call for the elimination of all hazards, just the "recognized" ones.

The goal of this book is to assist the safety and health manager in detecting hazards and in deciding which ones are worth correcting.

Safety Versus Health

What is the difference between safety and health? A machine guard is a safety consideration, and airborne asbestos is a health hazard, but some hazards, such as those associated with paint spray areas and welding operations, are not so easy to classify. Some situations may be both a health and a safety hazard.

This book will draw the following line between safety and health: safety deals with acute hazards, whereas health deals with chronic hazards.

An acute effect is a sudden reaction to a severe condition; a chronic effect is a long-term deterioration due to a prolonged exposure to a milder adverse condition.

Noise can be both acute and chronic; sudden exposure to high decibels or long term exposure to 90-100 decibels.

Degree of hazard is another point of contention between safety and health: both sides think their hazards are more grave. Safety professionals can point to fatalities on the job and feel an urgency in protecting the worker from imminent danger from accidents.

However there are probably more occupational health fatalities than safety fatalities, but the statistics will not reflect this difference because the health fatalities are delayed and are often never diagnosed.

Role In The Corporate Structure
Some safety and health managers are also personnel managers, and even more frequently they report to the personnel manager.

They can be responsible for training, statistics, job placement and industrial relations with respect to safety and health. Purchasing, however, is never associated with the safety and health manager’s responsibilities …..but according to the text should be. With respects to the purchase of new equipment, the sooner the Safety Manager gets involved in the purchasing process the sooner he can inject his opinion as to what is the safest equipment to purchase based upon a safety analysis.

A recent concept of the safety and health manager is as a liaison with government agencies, a condition brought about by the arrival of OSHA. Some safety and health managers have a dual responsibility for environmental protection (EPA) activities.

The consumer product safety commission (CPSC) concentrates on the responsibility of the manufacturers of the machines and equipment, whereas OSHA concentrates on the responsibility of the employer who places the equipment into use in the workplace.

Resources At Hand (Page 6)

A variety of resources have arisen to meet these needs of the Safety and Health Professional.

• Professional Certification

• Professional Societies

• National Safety Council

• Standards Institutes

• Trade Associations

• Government Agencies
  - free consultation
  - The National Institute For Occupational Safety And Health (NIOSH) has a wealth of research data on the hazards of specific materials and processes.
  -NIOSH uses these data to write criteria for recommended new standards.

  - OSHA itself can be of value to the safety and health manager who seeks information.

Chapter 2

Development of the safety and health function
To make workers aware of hazards, supervisors and the workers themselves need regular training in hazard recognition and correction.

Statistics and accident records are needed to keep management and operating personnel advised of how well the company and its departments are doing in achieving their safety and health goals.

Workers' Compensation

Workers' compensation provided an initial structure to industrial safety. The first such laws were introduced in state legislatures in 1909, and now all states have comparable legislation.

The purpose of workers' compensation legislation is protecting the worker by providing statutory compensation levels to be paid by the employer for various injuries that may be incurred by the worker.

This provokes labor to be dissatisfied with the workers' compensation system. Table 2.1 lists examples of statutory compensation levels.

Typically, the firm does not pay the workers' compensation payments directly; rather, it carries insurance against compensation claims.

"Experience Rating," expressed as a decimal fraction to be multiplied by the standard premium rate. The experience rating is based upon a three-year average of the firm's actual claims experience and can be less than or greater than 1.00.

The number of employees is not criteria used in the computation of premium rate (see Page 33).

A good insurance company will make regular inspections of facilities to be sure that installations and practices are safe. This is a direct and measurable monetary stimulus to the safety program.

Some companies choose to self-insure against workers' compensation claims. The insurance companies are valuable sources of technical advice to their clients.

The number of companies that have elected to self-insure has led to a new type of consultant called a Loss Control Representative. This consultant's objective is to keep workers' compensation claims low by supplying the type of services normally provided by the insurance carrier.

Recordkeeping
The national safety council established the first national system of industrial safety recordkeeping. This system was standardized and designated the z16.1 system by the American National Standards Institute.

In the 1970s, the Federal OSHA agency set mandatory recordkeeping requirements very similar to the z16.1 system.

Traditional Indexes

Familiar statistical measures are frequency and severity. Frequency measured the numbers of cases per standard quantity of workhours, and severity measured the total impact of these cases in terms of "lost workdays" per standard quantity of workhours.

Incidence Rates

The total injury/illness treatment incidence rate includes all injuries or illnesses which require medical treatment, plus fatalities.

Medical treatment does not include simple first aid, preventive medicine (such as tetanus shots), or medical diagnostic procedures with negative results.

First aid is described as "one-time treatment and subsequent observation of minor scratches, cuts, burns, splinters, and so forth, which do not ordinarily require medical care" and is not considered medical treatment even if it is administered by a physician or registered professional personnel.

Regardless of treatment, if an injury involves loss of consciousness, restriction of work or motion, or transfer to another job, the injury is required to be recorded.

The U.S Bureau of Labor Statistics has listed sample types of medical treatment, as shown in Appendix b considered to be recordable.

Appendix C gives examples of first aid given for injuries that are not normally recordable unless they qualify for recording for another reason, such as loss of consciousness or transfer to another job.

To compute the incidence rate, the number of injuries is divided by the number of hours worked during the period covered by the study and then is multiplied by a standard factor to make the rate more understandable.

\[
Total \ injury/illness \ incident \ rate = \left( \frac{\# \ of \ injury/illness}{\text{Total hours worked}} \right) \times 200,000
\]

Thus the total injury/illness incidence rate represents the number of injuries expected by a 100-employee firm in a full year, if injuries and illnesses during the year follow the same
frequency as observed during the study period. A typical data collection period is one year.

The term incidence rate is really a general term and in addition to the total injury/illness incidence rate includes the following:

1. Injury incidence rate
2. Illness incidence rate
3. Fatality incidence rate
4. Lost-workday-cases incidence rate (LWDI)
5. Number-of-lost-workdays rate
6. Specific-hazard incidence rate

Note the difference between rates 4 and 5. Rate 4 counts cases in which one or more workdays were lost or in which the worker was transferred to another job. Rate 5 counts the total number of workdays lost or in which the worker was transferred to another job.

In counting the number of lost workdays, the date of the injury or onset of illness should not be counted, even though the employee may leave work for most of that day.

The specific hazard incidence rate is useful in observing a narrow slice of the total hazards picture. For specific hazards, injury incidence, illness incidence, fatality incidence, and all of the other rates can be computed.

The most widely recognized standard incidence rate is the lost-workday-cases incidence rate, commonly known as the LWDI. A somewhat surprising characteristic of the LWDI is that it considers injuries only, not illnesses.

The LWDI is considered a more precise and robust measure of the effectiveness of the firm's overall safety and health program. Also, perhaps for the same reasons, the LWDI considers only lost-time injuries, not all injuries.

The LWDI was once used by OSHA as a criterion to determine whether to conduct a general inspection.

Today, the LWDI is applied to entire industries, as designated by the four-digit Standard Industrial Classification (SIC) number.

Whether an individual company actually receives an inspection, however, is subject to several additional factors, such as in which OSHA region and area it is located, the
available inspection resources in that region or area, how recently the firm has received an inspection, the number of high-priority requests such as major accident investigations or employee complaints that arise in that region or area, and the number of resources already committed for named target areas such as construction.

Recordkeeping Forms

The basic form is the log of occupational injuries and illnesses, OSHA Form 300 is displayed in Figure 2.3. Figure 2.4 shows the OSHA Form 300A which is a summary to required to be posted annually.

The summary is required to be posted in a prominent position in the workplace on February 1 each year and to remain posted until April 30. It is the employer's responsibility to enter data correctly into the log/summary. General records are required to be saved for a period of at least five years.

The person responsible for completing the log/summary may need some guidance in distinguishing between occupational injuries and illnesses.

Occupational injuries include lacerations, fractures, sprains, and amputations that result from a work accident or from an exposure involving a single incident in the work environment.

An illness is any abnormal condition or disorder, not classified as an injury, caused by exposure to environmental factors associated with employment. Illnesses are usually associated with chronic exposures, but some acute exposures can be considered illness if the exposure is the result of more than a single incident or accident.

Calculation of Incidence Rates from Case 2.1 Page 25-29

LWDI (injuries only) = 0.8

Injury Incidence Rate = 1.2

Illness Incidence Rate = 0.8

Fatality Incidence Rate =0.4

Number-Of-Lost-Workdays Rate =10.4

Specific Hazard Incidence Rate = 0.4
  (eye injuries)

The LWDI is calculated in a prescribed way that excludes all fatalities and all illnesses regardless of whether time was lost or not.
The LWDI is an incidence rate and should not be confused with the number-of-lost-workdays rate.

OSHA considers both days away from work and restricted work activity days as lost workdays. It is important to note that with respects to lost time calculations the new OSHA Standard uses calendar days instead of work-days. If, for instance, a worker was injured on Thursday and was not able to return to work on Monday the number of lost-time days is three (3); Friday, Saturday and Sunday.

The File 11 eye injury satisfied the Appendix c definition of first aid and thus, as a nonrecordable injury, was excluded from the calculation.

The required retention period for these general records is five years. However, in the early 1980s, special recordkeeping requirements were established for toxic chemicals, in the movement that became known as "right-to-know." The recordkeeping requirements for toxic chemicals are much more comprehensive and have led to the development of computer information systems for safety and health. The required retention period for hazardous chemical exposure records and medical records under the "right-to-know" standards is 30 years instead of five years.

**Accident Cause Analysis**

One of the important tasks of a safety manager is a thorough analysis of the potential causes of injuries and illnesses that have already occurred in the plant to prevent their recurrence.

Accident cause analysis and subsequent dissemination of this information to personnel who will be exposed to the hazards in the future is believed to be the most effective way of preventing injuries and illnesses.

**Case Study 2.2 Page 31**

Thus accident cause analysis is the foundation on which safety and health engineering, capital investment planning, training, motivation, and other functions are constructed.

**Organization of Committees**

Committees are appointed from the ranks of the operating personnel of the organization.

Sooner or later, everyone has his or her turn on a safety committee, which means that the direct activity of the safety and health program is a product of plant-wide participation.
Despite its advantages, there are pitfalls to the committee approach. The safety and health manager should provide resources and guidance to the committee so that it will have the necessary tools and knowledge to function effectively.

Safety And Health Economics

Safety and health managers sometimes base safety and health decisions on dollars and cents.

The prevention of employee injuries and illnesses can be formulated as an economic objective; such a formulation is more meaningful to management than vague humanitarian aspirations. Accidents, injuries, and illnesses have undeniable costs that contribute nothing to the value of products manufactured by the firm or services performed.

One category of costs from injuries and illnesses is the payment of workers' compensation insurance premiums, which are based on the firm's injury and illness experience.

Workers' compensation costs typically range from 1 to 2% of the total payroll of the firm.

Certain hazardous industries may have workers' compensation costs of around 3% of payroll; not the number of employees.

The national safety council, lists the following categories of hidden costs of accidents not covered by workers compensation:

1. Cost of wages paid for time lost by workers who were not injured.
2. Cost of damage to material or equipment.
3. Cost of wages paid for time lost by the injured worker, other than workers' compensation payments.
4. Extra cost of overtime work necessitated by the accident.
5. Cost of wages paid supervisors for time required for activities necessitated by the accident.
6. Wage cost caused by decreased output of injured worker after return to work.
7. Cost of learning period of new worker.
8. Uninsured medical cost borne by the company.
9. Cost of time spent by higher supervision and clerical workers on investigations or in the processing of compensation application forms.

10. Miscellaneous usual costs.

These are visually presented in Figure 2.8 on page 34.

Training

Training or training support may be the most important staff function to be performed by the safety and health manager.

The principal trainers in safety or health or in any other aspect of the job are first-line supervisors.

Recognizing that most training takes place between supervisor and worker, there is still a need for classroom training in safety and health principles, standards, and hazards recognition, especially for supervisors.

Drug and Alcohol Abuse

Drug and alcohol abuse has been shown to be a greater problem than was once thought.


Alcoa hired 130 of the 750 applicants who passed the test and, according to the personnel manager, found the people hired to be better workers than the company had before the drug screening program had been added to the hiring process.

There is no choice in certain sectors of the transportation industry subject to mandatory testing for marijuana, cocaine, opiates, amphetamines, and PCP, under rules issued by the U.S. Department of Transportation. The program prescribes random, pre-employment, periodic, reasonable cause, and post-accident testing.

A key question to ask management is whether they can imagine a situation in which the firm might some day need to terminate an employee because excessive drug or alcohol abuse has affected his or her job. If the answer is yes, the firm is exposed to litigation risks if a policy on drug and alcohol abuse is not in place.

EAP’s are organized to deal with the difficulties of employees who have a recognized drug or alcohol abuse problem.

The Smoke-Free Workplace
OSHA has already taken steps to deal with smoking in the workplace in advance of any workplace standards that deal specifically with this problem. OSHA officials have testified before congressional subcommittees addressing this problem.

In 1994 OSHA published a proposed rule on indoor air quality in the federal register. Although other indoor air contaminants are addressed, it is clear that tobacco smoke is the primary target of this proposed standard. In the case of tobacco smoke, employers would be required either to prohibit smoking in the entire building or to establish designated smoking areas.

Blood Borne Pathogens

The HIV virus has the spotlight because of the alarming growth of the epidemic. In the occupational arena the hepatitis B virus (HBV) actually kills more victims than does HIV.

Although the medical professions are the primary focus, the OSHA standard is not limited to these workplaces. The question to be asked is whether the worker will be exposed to blood or other potentially infectious materials, which includes some wastes and tissues of infected animals.

For workplaces that have one or more employees who may encounter occupational exposures, OSHA expects the employer to have a written exposure control plan. This plan must be accessible to employees and is subject to update at least annually. The employer must identify and list those jobs that are subject to exposure.

Workplace Violence

Workplace violence is the leading cause of occupational fatalities for working women and 2nd leading cause for men.

No standard exists yet but one is in the making.

Six risk factors:
1. Exchange of money with the public.

2. Working alone or in small numbers.

3. Working late at night or during early am.

4. Working in high crime areas.

5. Guarding valuable property or possessions.

Safety managers need to be alert and proactive with regards to these risk factors.

Chapter 3
Concepts of Hazard Avoidance

The objective of this chapter is to present four approaches that safety and health managers can use as tools to deal with the unknown elements of worker safety and health.

1. The Enforcement Approach
2. The Psychological Approach
3. The Engineering Approach
4. The Analytical Approach

1. The Enforcement Approach To Hazard Avoidance

Initially taken by OSHA, but OSHA was not the first to employ it; safety rules with penalties have existed almost since people first began to deal with risks.

The enforcement approach is simple and direct; there is no question that it has an impact.

Using the enforcement approach, OSHA has forced thousands of industries to comply with regulations that have changed workplaces and made millions of jobs safer and more healthful.

The enforcement approach has failed to do the whole job. It is difficult to see any general improvement in injury and illness statistics as a result of enforcement, although some categories, such as trenching and excavation cave-ins, have shown marked improvement.

Weaknesses of the enforcement approach include:

- Mandatory standards must be worded in absolutes, such as "always do this" or "never do that."
- Requires the anticipation of every circumstance to be encountered. Within the framework of the stated scope of the standard

Consider the following case study. Case Study 3.1 Page 50.

Now consider the following actual case. Case Study 3.2 Page 51.

A similar case. Case Study 3.3 Page 51.

Although OSHA later rescinded the fines in the Idaho trench-rescue case, one can see that the enforcement approach leads to problems when it is the only response to dealing with a
safety or health hazard. Sometimes a fine is a negative and inappropriate response in a vain attempt to place the blame, after the fact, when an accident has occurred.

2. The Psychological Approach To Hazard Avoidance

The psychological approach is an approach that attempts to reward safe attitudes. Elements of the psychological approach are posters and signs reminding employees to work safely. A large sign may be at the front gate of the plant displaying the number of days since a lost-time injury. Safety meetings, departmental awards, drawings, prizes, and picnics can be used to recognize and reward safe attitudes.

- Emphasizes the religion of safety and health versus the science. And are typified by attempts at persuasion, sometimes called "pep talks."

- Its very sensitive to the support of top management, and if such support is absent, the approach is very vulnerable. I. E. Management does not wear safety glasses when visiting the production floor.

- Young workers are especially influenced by the psychological approach. I. E. If highly respected co-workers laugh at or ignore safety principles, young workers may get off to a very bad start, never taking safety and health seriously.

Case Study 3.4 Page 53.

3. The Engineering Approach To Hazard Avoidance

For decades, safety engineers have attributed most workplace injuries to unsafe worker acts, not unsafe conditions. The origin of this thinking has been traced to H. W. Heinrich. His studies resulted in the widely known ratio 88:10:2:

<table>
<thead>
<tr>
<th>Causes</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsafe acts</td>
<td>88%</td>
</tr>
<tr>
<td>Unsafe conditions</td>
<td>10%</td>
</tr>
<tr>
<td>Unsafe causes</td>
<td>2%</td>
</tr>
<tr>
<td>Total causes</td>
<td>100%</td>
</tr>
</tbody>
</table>

The current trend is to give increasing emphasis to the workplace machinery, environment, guards, and protective systems.

Accident analyses are probing more deeply to determine whether incidents which at first appear to be caused by "worker carelessness" could have been prevented by a process redesign. This development has greatly enhanced the importance of the "engineering approach" to dealing with workplace hazards.

Three Lines Of Defense
When a hazard is identified the firm should first try to redesign or revise the process to "engineer out the hazard. Thus engineering controls receive first preference in what might be called three lines of defense against health hazards.

1. Engineering controls
2. Administrative or work practice controls
3. Personal protective equipment

Engineering controls deal directly with the hazard by removing it, ventilating it, suppressing it, or otherwise rendering the workplace safe and healthful.

Safety Factors
Engineers have long recognized the chance element in safety and know that margins of error must be provided.

The selection of safety factors is an important responsibility. It would be nice if all safety factors could be 10:1, but there are trade-off’s which make such large safety factors unreasonable, even infeasible, in some situations. Cost is the obvious, but not the only trade off. Weight, supporting structure, speed, horsepower, and size are all factors that may be affected by selection of too large a safety factor.

Fail-Safe Principles
These are additional principles of engineering design that consider the consequences of component failure within the system.

1. General fail-safe principle: the resulting status of a system, in event of failure of one of its components, shall be in a safe mode. Case Study 3.5 Page 55 & 3.6 Page 56.

2. Fail-safe principle of redundancy: a critically important function of a system, subsystem, or components can be preserved by alternate parallel or standby units.

3. Principle of worst case: the design of a system should consider the worst situation to which it may be subjected in use (Murphy's law).

Some Design Principles listed to stimulate thinking on how to reduce hazards:
1. Eliminate the process or cause of the hazard
2. Substitute an alternate process or material.
3. Guard personnel from exposure to the hazard.
4. Install barriers to keep personnel out of the area.
5. Warn personnel with visible or audible alarms.
6. Use warning labels to caution personnel to avoid hazard.
7. Use filters to remove exposure to hazardous effluents.
8. Design exhaust ventilation systems to deal with process effluents.
9. Consider the human interface.
Engineering Pitfalls

1. Certain unusual circumstances can make the engineering solution inappropriate or even unsafe.

2. Workers remove or defeat the purpose of engineering controls or safety devices. Case Study 3.7 Page 59.

3. The engineered system can sometimes cause a hazard. Figure 3.1 Page 60.

4. The Analytical Approach To Hazard Avoidance

The analytical approach deals with hazards by studying their mechanisms, analyzing statistical histories, computing probabilities of accidents, conducting epidemiological and toxicological studies, and weighing costs and benefits of hazards elimination.

1. Accident analysis: no safety and health program within an industrial plant is complete without some form of review of mishaps that have actually occurred.

2. Failure modes and effects analysis: sometimes a hazard has several origins, and a detailed analysis of potential causes must be made. Engineers use fmeFMEA to trace the effects of individual component failures on the overall or "catastrophic" failure of equipment. I.E. Preventive & Predictive Maintenance.

3. Fault tree analysis: concentrates on the end result, which is usually an accident or some other adverse consequence. Accidents are caused at least as often by procedural errors as by equipment failures. And fault tree analysis considers all causes—procedural and/or equipment.

Figure 3.3 Page 63 shows a sample fault tree diagram of the network of causal relationships that contribute to electrocution of a worker using a portable electric drill.

4. Loss incident causation models: is closely related to both the fault tree analysis and FMEA.

It’s a model that emphasizes the causes of "loss incidents," from a universal perspective in which the entire causal system is examined: primary causes (proximal causes) and secondary causes (distal causes) and the point of irreversibility.

5. Toxicology: is the study of the nature and effects of poisons. Industrial toxicology is concerned especially with identifying what industrial materials or contaminants can harm workers and what should be done to control these materials.

6. Epidemiological studies: epidemiology studies are strictly of people, not animals. Is derived from the word “epidemic” and in the literal sense is the study of epidemics.
The epidemiological approach is to examine populations of people to associate various patterns of possible disease causes with the occurrence of the disease. It draws heavily on the analytical tools of mathematical statistics. Case Study 3.8 Page 69.

Safety and health managers do not typically perform these studies, but they provide the basis for mandatory standards which are subsequently used in the enforcement approach.

7. Cost-Benefit Analysis: safety and health managers do make cost judgments on occupational safety and health issues because funds have limitations.

A cost-benefit analyses can be used to compare capital investment alternatives to justify capital investment proposals that can be shown to have the possibility of preventing injuries and illnesses

The biggest difficulty with cost-benefit analysis is the estimation of the benefit side of the picture.

Case Study 3.9 Page 70.

Hazards Classification Scale

OSHA recognizes four categories of hazards or standards violations as follows:

• Imminent Danger
• Serious Violations
• Non-Serious Violations
• De Minimus Violations

Loosely defined these are distinguished chiefly by the extent of the penalty authorized for each type.

A 10-point scale is recommended by this author. Table 3.1 Page 72 is a first attempt to describe subjectively each of 10 levels of hazards. Hazards classification scale

One critical test is met by the proposed scale, within each hazard type, each successive level of the scale describes a progressively more severe hazard.

Chapter 4
Impact of federal regulation
Federal safety and health regulations also include:
- MSHA - The Mine Safety And Health Administration
- TOSCA - The Toxic Substances Control Act
- CPSC - The Consumer Product Safety Commission

Standards

The most significant change that OSHA brought to industry was a book of federal standards; mandatory rules for worker safety and health.

This set of rules formed the basis for inspection, citations, penalties, and virtually every activity in which OSHA is engaged.

One rule, however, was not in the book;

**General duty clause**
Congress decided to set up one general rule for all to follow, and this rule was included in its entirety in the text of the law that created OSHA. This rule, called the general duty clause, might be called the first commandment of OSHA. It is quoted as follows:

Public Law 91-596

Section 5(a) each employer . . .(i) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees....

The General Duty Clause is cited by OSHA whenever a serious safety or health violation is alleged for which no specific rule seems to apply.

Public Law 91-596

Section 5(b) each employee shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this act which are applicable to his own actions and conduct.

Note that section 5(a)(1) describes a responsibility for employers, whereas section 5(b) pertains to employees.

**Structure**
The general book of standards, *General Industry*, Part 1910, was published to cover virtually all industries.


But even special categories of industries (i.e. construction) are also covered by the more General Part 1910 with respect to any hazard for which no standard exists.
Another classification for standards divides them into *specification* standards versus *performance* standards.

The *specification* type is easier to enforce because it spells out in detail (i.e. methods) exactly what the employer must do and how to do it.

The *performance* type permits the employer latitude in devising innovative ways to eliminate or reduce hazards (i.e. results).

Example 4.1 (Page 84-85)
(a) Example of a specification standard leaves no doubt in the reader's mind as to what must be done and specifies exactly the limitations of containers and manifolds within the room.
(b) Example of a performance standard it can be seen that employers have all kinds of latitude to set up their buildings in ways to avoid "undue danger."

**NIOSH**
The national institute for occupational safety and health (NIOSH) was established by the OSHA law to carry on research, training, and develops the criteria for new standards. NIOSH recommends new standards to OSHA which has the sole authority to promulgate new standards.

**Enforcement**

**Inspections**
OSHA has been given the authority to inspect, at a "reasonable time," industries and issue citations with monetary penalties.

Employers may invoke their fourth amendment rights and require OSHA to obtain a search warrant.

Priorities that generated OSHA inspections:

1. **Imminent Danger**: a situation in which death or serious physical harm could be expected to occur immediately. Time is of the essence. OSHA has a policy of investigating within 24 hours of notification.

2. **Fatalities And Major Accidents**: OSHA requires a telephone call or other notification within 8 hours upon occurrence of fatal accidents or accidents in which three or more persons are hospitalized. OSHA has a policy of investigating within 24 hours of notification.

3. **Employee Complaints**: an employee can request that OSHA investigate a hazard by filing with OSHA a complaint describing a hazard believed to exist in the
workplace. To be valid, the complaint must be signed by the employee. OSHA is bound by law to keep the origins of an employee complaint confidential if the employee requests.

4. High-Hazard Industries: industries that are shown by statistical records to be particularly hazardous referred to as target industries whose national LWDI average (sic classification) is higher than the national average LWDI for all industries.

Citations
OSHA may issue a citation for alleged violations of the standards or of the general duty clause. The statutory limit is six months, so if no citation has been received within six months, the employer can be assured that a citation will not be forthcoming.

OSHA may issue a de minimus notice (a violation of the letter of the law) in lieu of a citation which do not carry a monetary penalty.

The citation must be prominently posted near where the violation occurred.

Table 4.1 OSHA Penalties (Page 88)

Although most OSHA penalties are small, it is possible for fines to become quite severe. Note that the failure-to-abate penalty is assessed for every day a violation remains uncorrected. Although rare, some willful and repeat violations have resulted in fines of hundreds of thousands of dollars assessed on a single firm.

An additional category, egregious violation, was established administratively in the 1980s by the agency. Worse than a willful violation, an egregious violation is a glaring or flagrant violation, which may invoke even higher penalties. Citation of egregious violations requires clearance from OSHA's national headquarters in Washington, DC.

The following questions are frequently asked in seminars about OSHA:

1. Who in the organization goes to prison when the "employer" is found to be guilty of a willful violation resulting in death?

2. Where does the money collected in OSHA fines go—to OSHA’s budget to pay inspectors?

There is a 15-day period (working days) after receipt of the citation during which a decision must be made whether or not to contest the citation.

Employee Discrimination
Employers are subject to punishment if they are found to have discriminated against an employee because that employee filed an OSHA complaint or answered the OSHA
compliance officer's questions during an inspection or exercised any other right afforded employees under the OSHA law.

OSHA takes seriously these examples of employee discrimination with respects to OSHA:

- termination
- demotion
- assignment to an undesirable job or shift
- denial of promotion
- threats or harassment
- blacklisting the employee with other employers

Safety and health managers should ensure that all managers and careful not to discriminate either directly or indirectly against any employee for complaining about safety and health violations.

Role of The States

The OSHA law provides for state plans to be submitted to OSHA for approval.

Enforcement
OSHA itself has been given no authority to regulate state agencies, counties, or municipalities. Even federal agencies are exempt from regular OSHA enforcement.

The OSHA law does provide for federal agency coverage as a part of the responsibilities of the heads of the various federal agencies.

If a state submits a plan for occupational safety and health standards and enforcement, they must be at least as effective as the corresponding federal standards and enforcement usually they are identical to the federal OSHA standards (Appendix g).

Consultation
OSHA delegates to states authority and responsibility for consultative assistance in occupational safety and health to employers upon request. There is no charge for state consultation, and as of this writing it was available in some form in every state.

Political Trends

OSHA appears to be quite durable and has survived repeated attempts to repeal or modify it.

Positive Developments
The number of university academic programs in safety and health had tripled since 1970.
OSHA has become increasingly interested in training and in the effectiveness of employee committees for safety and health.

SHARP Program is designed to provide recognition to small companies that cooperate and participate in OSHA’s consultation program. The employer must:

1. receive a comprehensive safety and health consultation visit.
2. correct all workplace safety and health hazards.
3. adopt and implement effective safety and health management systems.
4. agree to request further consultative visits if major changes in working conditions or processes occur that may introduce new hazards.

The reward is an exemption from OSHA programmed inspections for a period of one year.

VPP Program is the Voluntary Protection Program which involves a serious commitment on the part of the employer to maintain an exemplary safety and health program for its employees. There are three steps of recognition:

Step 1. Demonstration which identifies the company as seeking recognition from the VPP program.

Step 2. Merit is awarded after lengthy series of steps and the firm qualifies for the next rating.

Step 3. Star (the highest) which is reserved for outstanding safety and health programs.

Ergonomics

Ergonomics is the study of human capability in relation to the work environment, and solutions to ergonomics problems usually require a sophisticated analysis involving perhaps a redesign of the work station to fit the process. An example is the problem of carpal tunnel syndrome, a chronic illness of the wrist that occurs due to repetitive hand motion.

Extra-Hazardous Employer Status

An employer receives this designation when notified by the Workers' Compensation Commission of the state of the company's residence. The designation is determined by a calculation of the company's lost-time injuries incidence rate and comparison with the "expected rate" for that company's industry (SIC). When the company's rate exceeds the level that can "reasonably be expected" for that industry, the company is designated an "Extra-Hazardous Employer."

Being dubbed "extra hazardous" carries with it certain responsibilities for management. The first of these is to have a safety consultation within a short time period, usually 30 days. Options for this consultation may include the state labor department, the company's
insurance carrier, or a professional consultant approved by the Workers' Compensation Commission of the state of residence.

The written report of the safety consultant is then used by the company as a basis for the development of a mandatory "accident-prevention plan." The plan must be more than a general document; it must address each of the hazards or unsafe practices identified in the safety consultation report. The plan must also include provision for the following:

1. statement of company safety policy
2. analysis of hazards
3. recordkeeping
4. education and training
5. in-house audits or inspections
6. accident investigations
7. periodic review of abatement effectiveness
8. implementation schedule

**Americans With Disabilities Act (ADA)**

The ADA has had a significant impact on the field of worker safety and health. Because it has been common practice to discriminate against job candidates (whose safety or the safety of their co-workers may be at stake if these candidates have physical or mental impairments) that might affect the particular job for which they are being hired.

Case Study 4.1 page 100 gives insight into these practices and the ramifications of such.

**Chapter 5**

**Information Systems**

Because it is impossible for the employer to completely eliminate all hazards OSHA shifts some of the responsibility to the employee by requiring information systems that educate employees about the nature and degree of hazards associated with the job. Employees are thus given the necessary data with which to evaluate the risks and take action accordingly.

Thus began; the Right-To-Know, regulations requiring Material Safety Data Sheets (MSDSs), and the labeling of hazardous materials to which employees or the public might become exposed. Note: not all materials only hazardous ones.

**Hazard Communication**

**Container Labeling**

The hazard communication standard placed the labeling and MSDS responsibility upon the manufacturer or importer of the substance.

Some substances are excluded:
• pesticides
• food, drugs, or cosmetics
• alcoholic beverages
• substances covered by the labeling requirements of the consumer product safety commission (CPSC)
• hazardous wastes
• tobacco or tobacco products
• wood or wood products
• "articles"

In some cases it may be difficult to distinguish between articles and materials.

**Material Safety Data Sheets**
The standard lists specific categories of information that must be included in the MSDS.

Figure 5.1 (Page 107-108) is an exhibit of a blank form in a generic format.

**Employee Hazard Communication Program**
The responsibility for protection of employees from potential exposure becomes the responsibility of the employer. A principal requirement is that employers have a written hazard communication program.

One required component is a list of the hazardous chemicals known to be present in the workplace and a MSDS must be on hand and available to employees.

Federal standards permit the MSDS to be kept in any form, even within operating procedures.

The safety and health manager should ensure that the required information is available for each hazardous chemical and that the information is readily accessible to employees of each work shift.

In addition, the employer must maintain the labels provided by the manufacturer or importer of the substance, except that labels are not required for portable, in-house containers intended for immediate use.

**Record Retention**
Records information systems should be present that trace the identities, location of use, and time of use for hazardous substances, along with each employee exposure, for a retention period of at least 30 years.

Employee medical records must be preserved and maintained for the duration of employment plus 30 years.
Sale of the business or closing the business does not relieve the employer of the record-retention responsibility. The employer may be required to transfer the records to NIOSH, depending on the requirements of specific standards pertaining to the hazardous substances in question.

Environmental Protection Agency

**Medical Surveillance**
Fundamental to the right-to-know concept is the employees' right of access to their personal medical records held by the company that employs them. A medical surveillance program is required for

1. All employees who may be exposed to health hazards at or above the established permissible exposure limits for 30 days or more a year, whether or not the employee uses a respirator for protection against the hazards.

2. All employees who wear a respirator for 30 days or more a year.

3. Employees designated by the employer to plug, patch, or otherwise temporarily control or stop leaks from containers that hold hazardous substances or health hazards (i.e., members of hazardous material (HAZMAT) teams).

Federal standards prescribe intervals at which medical examinations and consultations shall be made. The regular times are as follows:

1. Prior to assignment to duties that may require hazardous material exposure.

2. At least every 12 months during assignment to such duty.

3. Upon termination of such duty, unless the employee has had an examination within the last six months.

A medical examination is required as soon as possible if an employee develops signs or symptoms indicating possible overexposure or if an unprotected employee becomes exposed in an emergency situation.

**Reporting**
Facilities in the manufacturing industries (sic codes 20xx through 39xx) that use listed toxic substances in quantities over 10,000 pounds in a calendar year are required to submit toxic chemical release forms (EPA Form R) by July 1 of the following year.

For firms that manufacture or process these materials, the threshold quantity is 25,000 pounds per year, for amounts above which the firm is required to submit the toxic chemical release form.
For firms that both manufacture and use the same substance, if the threshold quantity is exceeded in either instance, then the firm must report, a point illustrated by case study 5.1.

Case Study 5.1 & 5.2 Page 113.

Chapter 6
Process Safety and Disaster Preparedness

Of major impact upon the field of safety and health management in the early 1990s was the promulgation by OSHA of the standard for process safety management of highly hazardous chemicals. The decade of the 1980s was witness to major tragedies involving explosions and catastrophic release of hazardous chemicals that resulted in numerous fatalities both to employees and the general public. These tragedies were of such significance as to attract worldwide attention.

These disasters prompted OSHA to seek more than an after-the-fact approach with inspections and fines. The result was a new standard that sought to forestall such catastrophes in the future. The resulting OSHA process safety standard was made effective in 1992.

Chapter 7
Buildings and Facilities

This book now turns to the business of examining hazards in various categories, highlighting applicable standards and suggesting methods of bringing about change to eliminate or reduce hazards.

Safety standards for buildings (municipal, state, or federal) are usually called codes. Building codes usually apply to the construction of new buildings or to their modification.

Some federal standards for buildings have been applied to all buildings, regardless of age. The standards have included matters of relative permanence such as floors, aisles, doors, numbers and locations of exits, and stairway lengths, widths, riser design, angle, and vertical clearance.

Federal standards pertaining to buildings and facilities include the following categories:

1. Walking-working surfaces
2. Means of egress
3. Powered platforms, manlifts, and vehicle-mounted work platforms
4. General environmental controls
1. Walking and Working Surfaces

Many accidents, especially slips and falls, occur on floors, and other walking and working surfaces i.e. mezzanines and balconies, platforms, catwalks, and scaffolds, ramps, docks, stairways, and ladders.

Guarding Open Floors and Platforms
The most frequently cited standard in the walking-and-working-surfaces subpart is indeed one of the most frequently cited standards in all of the OSHA standards. It is repeated here in its entirety, due to its importance.

OSHA standard 1910.23—guarding floor and wall openings and holes (Page 133)
(c) protection of open-sided floors, platforms, and runways
(i) every open-sided floor or platform 4 feet or more above adjacent floor or ground level shall be guarded by a standard railing or the equivalent as specified in paragraph (e)(3) of this section] on all open sides, except where there is entrance to a ramp, stairway, or fixed ladder. The railing shall be provided with a toeboard wherever, beneath the open sides,
(i) persons can pass,
(ii) there is moving machinery, or
(iii) there is equipment with which falling materials could create a hazard.

To many people, 4 feet seems an innocuous height but few adults experience a fall from that height without injury. A surprising number of fatalities result from falls at heights of only 8 feet.

OSHA specifies the protection of personnel from falls from:
• Loading docks by the installation of removable railings, and/or chain-type gates.

• Rooftop unless:
  1. The roof has a parapet.
  2. The slope of the roof is flatter than 4 inches in 12 inches.
  3. The workers are protected by a safety belt attached to a lifeline.
  4. The roof is lower than 16 feet from the ground to the eaves.

• Top of tanks are considered a “working surface.”

The term standard railings mentioned in the platform guarding standard is further clarified by federal standards, and salient features are shown in Figure 7.1.

In OSHA standard 1910.23(c)(1) sites three conditions which calls for a toeboard. Toeboards are vertical barriers along the exposed edges of the walking or working surface to prevent falls of materials. A standard toeboard is 4 inches high and leaves no more
than a 1/4-inch gap between the floor and the toeboard. If the toeboard is not of solid material, its opening must not be greater than 1 inch (Figure 7-1 Page 135).

**Floors and Aisles**
The most important consideration for floors and aisles is how they are maintained. Federal standards for housekeeping require areas to "be kept clean and orderly and in a sanitary condition."

What constitutes "clean and orderly and in a sanitary condition"? There is no clear-cut answer, but some information can be obtained from past OSHA citations:

**Example 7.1 Page 136**
In the railroad yard area of a steel manufacturing industry, piles of debris such as railroad ties and cables were lying about close to the track and presented tripping hazards to employees who must work in the area of the tracks. A complicating factor was that some of the debris was hidden by weeds.

**Example 7.2 Page 136**
Dangerous accumulations of grain dust were found in many locations in a grain elevator. The dust was sufficiently concentrated so as to not only be a health hazard to cleanup personnel but also to present a serious explosion hazard. Since the condition had been cited before, the citation was established as "serious and repeat," and the penalty was set at $10,000.

**Example 7.3 Page 136**
A cluttered workshop had obstructions that some of the employees had to step over or go around to do their jobs.

**Example 7.4 Page 137**
Leaking hydraulic cylinders dripped oil on the floor in a work area. No one was responsible for cleaning up the leaked oil.

*Excessive* is generally considered to be a material accumulation (in the immediate work area) in quantities in excess of what is actually required to do the given job, or scrap material lying hazardously about the work area in excess of a day's accumulation.

A prime measure of whether a housekeeping program is inadequate is the number of accidents such as trips and falls occurring in the area.

Water on the floor is a problem in many industries, and constant surveillance becomes necessary to assure that the floor is kept clean and dry.

Trip hazards due to uneven floors can result in serious injury.
Standards for aisles specify that permanent aisles be kept clear of hazardous obstructions and that they be appropriately marked.

Conspicuously absent from federal standards for aisles is a specific minimum width for aisles.

State codes which reflect the National Fire Protection Association's Life Safety Code often specify a minimum exit access width of 28 inches. But the federal code is silent on this point except to use the language "... Sufficient safe clearances shall be allowed ..."

These standards are therefore good examples of "performance standards."

The aisle-marking standard was formerly a specification standard but is now a performance standard.

Federal standards require marking plates for floor loads approved by the "building official."

Consulting a competent professional engineer would show a good-faith effort to comply with the standard and would virtually eliminate the possibility of a hazard.

**Stairways**

Building codes and standards for stairways are well established.

If the stairways have four or more risers, they need standard railings or handrails and must be kept clear of obstructions.

A handrail, as used in this standard, is a single bar or pipe supported on brackets from a wall to furnish a handhold in case of tripping.

A railing is a vertical barrier erected along the exposed sides of stairways and platforms to prevent falls.

The placement of stairway landings is a safety consideration. The main purpose of the stairway landing is to shorten the distance of falls, and thus landings play an important role in building and facilities safety. Extremely long flights of stairs are obviously more dangerous than stairs interrupted by landings. To be effective they must be no less than the width of the stairway and a minimum of 30 inches in length measured in the direction of travel.

**Ladders**

Safety and health managers should make sure that the ladders were constructed and maintained properly and are used in a safe fashion.
Defective ladders must be either repaired or destroyed, and while awaiting either fate they must be tagged or marked "dangerous; do not use.

Portable metal ladders conduct electricity. Rubber or otherwise nonconducting feet are a good precaution on metal ladders, but the hazard is still present.

A common error is to use ladders that are too short. When accessing a roof, the ladder needs to extend at least 3 feet above the upper point of support.

The first consideration in the use of a portable ladder is its condition, especially the rungs. Next is weather or not it is insecurely positioned. The proper slant is 4 feet vertical to 1 foot horizontal. A safe practice is to tie off the ladder at the top so that it cannot tip or slide down.

**Fixed Ladders**
With fixed ladders, the emphasis is on design and construction.

Problems they may be encounter with fixed ladders are illustrated in Figure 7.3 (Page 142).

Ladder standards prescribe breaking long lengths, and separating successive lengths, of a ladder by using an offset equipped with a landing platform.

Such offsets are required every 30 feet of unbroken length. When the fixed ladder is more than 20 feet long but less than 30 feet long, protective cages are needed. On tower, water tank, and chimney ladders over 20 feet in unbroken length, ladder safety devices may be used in lieu of cage protection. A ladder safety device is illustrated in Figure 7.4 (Page 143).

**Exits**
Exits are usually doors to the outside and from a safety standpoint are considered a means of escape, especially from fire.

The more general term means of egress to include

1. The way of exit access
2. The exit itself
3. The way of exit discharge

The safety and health manager should analyze the entire building to determine whether every point in the building has a continuous and unobstructed way of travel to a public way.

Outside the building one must think of yards, exterior storage of materials, fences, courtyards, and shrubbery.
Exits that are locked can be a two-edged problem because many safety and health managers are also responsible for plant security.

Facilities designers are turning more and more to the use of unlocked, automatic-alarm-sounding emergency exit doors.

More frequently encountered are exits that are cluttered or blocked by obstructions.

According to OSHA these are four major (or biggest) problems with exits:
1. locked exits
2. cluttered or blocked by obstructions
3. inadequate lighting, or the lack of it
4. improper exit signs and/or not suitability illuminated

**Americans With Disabilities Act**
Attention to buildings and facilities assumed increased significance with passage of the Americans With Disabilities Act (ADA) in 1990.

Many changes to walking and working surfaces, exits, drinking water fountain levels, rest rooms, and other facilities became mandatory instead of voluntary. Often, the safety and health manager has been assigned the responsibility for compliance with ADA.

**Illumination**

Lighting, or the lack of it, can be a safety hazard, but there is no code for minimum safe lighting except for specialized areas.

Every exit sign should be suitably illuminated by a reliable light source giving a value of not less than 5 foot-candles on the illuminated surface. Table 7.1 on page 145 gives some examples.

**Miscellaneous Facilities**

**Maintenance Platforms**
Typical problems with these platforms are missing guardrails, missing toeboards, missing side mesh, disabled safety devices, inadequate inspections or records of inspections, and for not having load-rating plates on the platform.

Workers on some types of powered platforms need to wear safety belts

Public-utilities workers and tree trimmers often use platforms that are vehicle-mounted, such as aerial baskets, aerial ladders, boom platforms, and platform-elevating towers. The most serious hazard with vehicle-mounted platforms is contact with high-voltage power lines.
A safe distance must be maintained at all times, the accepted standard is a 10-foot distance in the case of a 40-kilovolt line.

**Elevators**
Elevators must be inspected both when new (or altered) and periodically thereafter. Many states even require construction permits from the authorized elevator inspection agency before elevator construction is begun. Elevator operating permits and fees are also required by some states.

**Chapter 8**
**Ergonomics**

A. FACETS OF ERGONOMICS
Ergonomics is a multidisciplinary science that studies human physical and psychological capabilities and limitations. This body of knowledge can be used to design or modify the workplace, equipment, products, or work procedures to improve human performance and reduce the likelihood of injury and illness.

From the definition, it can be seen that the field of ergonomics covers a broad spectrum of activities involving human activity. Reducing the likelihood of injury or illness, as beneficial as that goal is, is only one of the objectives of the field. Improving human performance is another key objective, and, historically, may even be more important to the field of ergonomics.

1. Ergonomic Vehicle Design for Human Performance
Is the appropriate interface between human and machine to achieve the best possible result of the machine performing the intended task for the operator controlling it. If the equipment being designed is a vehicle, there are obvious implications for safety, not only of the operator, but also of the general public.

2. Designing Safety Features into Workplace Machines
In the design of machine controls, there are many features which are specified by safety standards. One example is the design of punch press footswitches. A properly designed standard footswitch for activating a mechanical power press has a cover to prevent the operator or other personnel from accidentally stepping on the pedal or switch, thus causing an accidental cycle of the press ram, which could have disastrous results. Another example is the requirement that crane pendant controls be "dead-man" controls. Case Study 8.1 Page 154-155 as an example.

3. Controlling the Work Environment
Focuses on the physical environment that surrounds the worker in the workplace. For most workplaces, the most important consideration in this regard is temperature. What limits of hot and cold temperatures are reasonable for the work environment, and what
temperatures are optimal for various tasks? Ergonomics attempts to scientifically determine these temperature parameters and apply them to the workplace. Humidity is also a factor. Sometimes the demands of the job require a worker to work in a hot or a cold environment, and the consideration then becomes a matter of appropriate duration.

Another aspect of the air, besides its temperature or humidity, is pollution. In this regard, OSHA and other regulatory agencies pay close attention to acceptable levels of pollution by various toxic air contaminants.

4. Manual Lifting
Ergonomics is more focused upon lifting, because it depends upon the human operator and applies stresses upon the human body. Manual lifting is one of the most studied subjects in ergonomics, but to date the studies are still inconclusive.

4. Back Belts
Supporting belts worn around the waist are often worn by persons who do heavy lifting as a part of their job. The implication is that such belts prevent injury to the lower back. NIOSH decided to test this assumption in a preliminary study reported in 1994 and again in the late 1990s in what has been described as "the largest study of its kind ever conducted." The study examined incidence rates for workers' compensation claims for back injuries. The following comparisons were made:

(a) workers who wear back belts everyday vs. those who never wear them or, if they do wear them, do so only occasionally (once or twice per month);

(b) employers that require back belts vs. employers for whom back belt use is voluntary.

Both hypotheses showed no statistical significance in the difference between the groups in the incidence rates for workers' compensation claims. Besides the workers' compensation claims, the study also examined "self-reported back pain" and again the results showed no statistical significance in the difference between the groups. The study lasted two years and involved interviewing 9377 employees at 160 stores nationwide.

5. Accommodating Individual Worker Characteristics
We know that it is difficult to eliminate the hazards of manual lifting by training in proper lifting techniques or in the screening of personnel for the job. Therefore the engineering approach to eliminate the need for manual lifting or to assist the worker by providing lifting aids is a desirable solution as it eliminates the hazard to the employee. For heavy lifting tasks, simple carts and dollies, as shown in Figure 8.1 on page 159, have been necessary and desirable in general industry for decades, even before the age of ergonomics.

More recently, lift tables, as shown in Figure 8.2 on page 160, have been used to facilitate the manual loading of workstations without requiring the worker to lift from the floor or
pallet. The field of ergonomics has provided considerable motivation to use the types of devices shown in Figure 8.2. Sometimes the solution can be as simple as delivering material to be processed onto a platform raised to the proper height without the necessity of employing a lift table. The benefits for large, awkward workpieces is evident in Figure 8.3 on page 160.

B. WORKPLACE MUSCULOSKELETAL DISORDERS
This complicated term is actually a generalization of more specific maladies that have been experienced in the workplace and have received significant attention on the part of both industrial safety and health managers and enforcement authorities. It is this part of ergonomics that has led to so much controversy and subsequent political action reaching a level as high as the U.S. Congress. A little history of the jargon surrounding these specific ailments leading up to the current emphasis on MSDs is in order.

1. Carpal Tunnel Syndrome
Carpal tunnel syndrome is a painful, possibly disabling dysfunction of the wrist. The condition is not clearly defined, but is generally thought to result from activities that require repetitive hand motion especially when the hands are required to be in an awkward posture. Tasks involving rapid production, such as assembly or typing, are often associated with carpal tunnel syndrome. Figure 8.4 illustrates a cross section of the wrist showing the crowding together of tendons, bones, and nerves within a sheath enclosed by the carpal ligament. The parts of the wrist must move within this sheath to give motion to the fingers in repetitive operations. It is understandable that awkward postures of the hand and wrist would further constrict the carpal tunnel area and give rise to discomfort from the moving parts. It also makes sense that highly repetitive motions would exacerbate the condition.

2. Repetitive Strain Injuries
OSHA reasoned that the carpal tunnel is not the only part of the body that could be irritated by repetitive motion. What about the neck, for instance? Did not workers get sore necks from jobs that required repeated motion of the head? And then there were sore elbows and sore shoulders. Therefore, the target "hazard" was shifted from "carpal tunnel syndrome" to a much broader term: repetitive strain injuries (RSIs). The term carpal tunnel syndrome went completely out of vogue among practicing professionals in the field because it limited the perspective of the practitioner as well as the enforcement powers of the regulatory officials. By the 1990s, the term carpal tunnel had become so out of style that it was conspicuously omitted from the definitions in the ANSI standard for ergonomics, and it is only briefly mentioned in the body of the standard as one of several different manifestations of disorders resulting from ergonomics hazards (ref. Work-Related).

3. Cumulative Trauma Disorders
Even the term RSI was too limiting in scope. Certainly rapid, repeated motions were the most common exposures associated with sore tendons and joints, but some workers were found to experience symptoms even when their jobs did not require this type of activity.
An even broader term was needed that would cover any type of trauma resulting from an accumulation of exposure over a period of time, though the worker is not injured from an occasional exposure. Thus, the term cumulative trauma disorders (CTDs) replaced RSIs. The word cumulative apparently carries more weight than the word trauma, because CTDs are generally considered a chronic exposure, not an acute one. The term CTD had a short life in the late 20th century, but has since been replaced with another term, MSD.

4. Musculoskeletal Disorders
The problem with CTD was that the term itself implied a cause of the condition. It seemed inappropriate to assume that the worker had been injured from an accumulation of exposure to a hazard. Even worse, suppose a worker complained about pain in a joint and it could not be established that the worker had cumulative exposure of any kind?

So as not to overlook any cause of the disorder, whatever the cause might be, the term musculoskeletal disorders (MSDs) became the new term used to describe all of the related worker conditions of this type, including carpal tunnel syndrome, rotator cuff syndrome, DeQuervain's disease, trigger finger, tarsal tunnel syndrome, sciatica, epicondylitis, tendinitis, Raynaud's phenomenon, carpet layers' knee, herniated spinal disc, low back pain, bursitis, and tension neck syndrome (ref. OSHA standard 1904.12(b)(1) and Work-related).

The term MSD was modified slightly in the ANSI standard to narrow the focus to work-related exposures. Therefore, as of this writing, the term had finally morphed into work-related musculoskeletal disorders, WMSDs. Figure 8.5 page 164 illustrates the historical progression in recognizing WMSDs.

C. AFFECTED INDUSTRIES
Two landmark citations by OSHA in the area of ergonomics have been used as a model for the formulation of enforcement policy for controlling the hazard of WMSDs.

1. Beverly Enterprises, a widely distributed provider of healthcare services (especially nursing homes) headquartered in Ft Smith, Arkansas. A principal concern in the nursing home industry is heavy manual lifting on the part of nurses and health-care providers.

2. Pepperidge Farms in Downingtown, Pennsylvania, a maker of biscuits. A principal concern in the food manufacturing and processing industry is carpal tunnel syndrome and other chronic repetitive motion maladies. Meat packing, especially poultry processing, has been another industry that has had considerable Section 5(a)(1) General Duty Clause enforcement actions brought against employers by OSHA.

D. ERGONOMICS STANDARDS
Citation of Section 5(a)(1) of the General Duty Clause for ergonomics hazards was always a stopgap measure that was used in the absence of a relevant, specific standard for
ergonomics. Therefore, throughout the decade of the 1990s, OSHA maintained a goal of developing a standard specifically focused on ergonomics.

1. OSHA Ergonomics Standard
The development effort climaxed in the waning weeks of the Clinton presidential administration as OSHA officials pushed to get a standard on the books before the Bush administration took office. In this, they succeeded with the "11th-hour" final standard officially announced in the Federal Register November 14, 2000. The standard allowed industries 11 months to come into compliance, targeting October 15, 2001, as the effective date.

After nearly a decade of negotiation, the final standard emphasized the following main areas:
   1. information to employees
   2. quick-fix action to eliminate reported WMSDs that meet the "action trigger" de
   3. fined by the standard or establishment of an ongoing WMSD program

The OSHA Ergonomics standard had a short life. As soon as the new Congress took office in 2001, the new Ergonomics standard was repealed by congressional vote, overriding OSHA’s action. When Congress overrides and repeals any agency action, that agency is prohibited from resubmitting a slightly different version in a new promulgation.

2. OSHA Guidelines
The new OSHA administration ushered in with the Bush administration and the new Congress abandoned the strategy of promulgating a specific standard for ergonomics. In its place, OSHA unveiled a plan to issue guidelines to help control ergonomics hazards. OSHA would issue the guidelines for specific industries and encourage other general industries to construct guidelines of their own. The new strategy emphasized cooperation and the use of exemplary, successful, established ergonomics program as models for assisting other industries. There was a provision for giving recognition to noteworthy ergonomics programs. There is no question that the new "guidelines" program emphasized the positive and relied on the judgment of the industries to take the initiative in developing programs to foster ergonomics solutions to problems and hazards. Indeed, OSHA pointed to Bureau of Labor Statistics reports that a decline in WMSDs had already been observed.

D. WMSD MANAGEMENT PROGRAMS
At this point, one may be wondering what plan to follow to have an effective Workplace Musculoskeletal Disorders program within a given company or plant. It is good strategy to have a working, documented program in place in any workplace that has exposure to hazards that can be categorized as related to WMSDs. It makes sense from the basis of

   1. worker comfort and basic well-being
   2. plant productivity
   3. reduction of workers' compensation claims
4. compliance with the safety and health General Duty Clause

Drawing from the consensus of both the ANSI standard and the proposed OSHA standards, the general components that follow are thought to make up an effective WMSD program.

1. Administration and Support
The program should have both documented and real management support. Employees and supervisors should be trained in the causes and symptoms of WMSDs and be encouraged to report problems. The training also should consider the workplace and the tools and work equipment used to do the work. Proper use, maintenance, and adjustment of these tools and equipment may forestall future occurrences of WMSDs.

2. Surveillance
This facet of the program insures that signs and cues will be used to signal the need for job analysis and the implementation of the principles of ergonomics. One sign of a need might arise from the review of injury and illness records in the facility. Another sign might be reports from employees, either of actual WMSD symptoms or perhaps just an employee concern about a situation that might carry a risk of WMSD exposure. The ultimate surveillance tool is an actual survey of any job suspected to be the cause of WMSDs.

3. Case Management
At the very least, an effective program should respond to WMSD cases as they are reported. This means that provision should be made for diagnosis, treatment, and recognition of necessary time for sufficient and timely recovery from the symptoms of WMSD exposures.

4. Job Analysis
The primary objective of job surveys is fact finding. Job analysis, by comparison, is a more detailed and comprehensive study of the workstation and task and is triggered by medical evidence that the workstation or job is the cause of WMSD exposure. With job analysis comes the evaluation of "risk factors" that contribute to the problem. A possible risk factor would be an unusually cold temperature ambient to the workstation. Another might be the posture required for a particular job. Certainly, the amount of force required to be applied and the number of repetitions of a given motion have possible effects upon the incidence of WMSDs.

Chapter 9
Health and Environmental Control
Industrial hygienists have been saying for many years that health hazards deserve more attention, in response to this pressure, a shift from safety toward health activities has been in evidence almost since OSHA began operations.

Health hazards will always tend to be more subtle to detect than safety hazards.

Baseline Examinations

The pre-employment physical examination establishes a baseline health status for employees.

Toxic Substances

Exposure to toxic substances is the classic "health problem."

This book follows popular convention, which tends to associate the term materials with safety hazards and the term substances with health hazards.

Irritants

Irritants inflame the surfaces of the parts of the body by their corrosive action.

When the irritant is some type of dust, the lung disease that results is called pneumoconiosis. This is a general term that includes reactions to simple nuisance dusts as well as fibrosis. The more dangerous fibroses are asbestosis (from asbestos fibers) and silicosis (from silica).

Chronic exposure to irritants over a long period can cause scar tissue to develop in the lungs. The most notorious of these scarring agents is asbestos fibers.

Coal dust is also a scarring agent. Scarring agents are in the form of tiny solid particles, and their action on the lungs is mechanical.

Systemic Poisons

Are poisons that attack vital organs or systems of organs, sometimes by toxic mechanisms.

The best known systemic poison found in occupational exposures is lead. Lead is disappearing from paint pigments because of its reputation as a poison, but it still exists in tetraethyl lead used in leaded gasoline.

Other toxic metals are mercury, cadmium, and manganese.

Two systemic poisons are: carbon disulfide, and methyl alcohol (methanol).

Depressants
Certain substances act as depressants or narcotics on the central nervous system and as such can actually be useful as medical anesthetics; methyl alcohol, ethyl alcohol, Acetylene, and benzene.

Asphyxiants
Asphyxiants prevent oxygen from reaching the body cells, and in the general sense, any gas can be an asphyxiant if there is enough of it to crowd out the essential proportion of oxygen in the air; methane, argon, helium, nitrogen, and carbon dioxide. Case Study 9.1 on page 175.

The asphyxiants discussed so far are simple asphyxiants, essentially nontoxic substances which replace the essential oxygen content in the air. Case Study 9.2 on page 176.

Chemical asphyxiants interfere with the oxygenation of the blood in the lungs thus the oxygenation of tissue; carbon monoxide and hydrogen cyanide.

Carcinogens
Carcinogens are substances that are known to cause or are suspected to cause cancer.

New carcinogens are being labeled every year, i.e. vinyl chloride

Teratogens
Teratogens affect the fetus, so their toxic effect is indirect. Women should be careful about exposures to certain substances during pregnancy, especially in the first trimester (first three months).

A tricky legal question is whether an industry can prohibit women of childbearing age from working in jobs in which they may be exposed to teratogens.

Routes Of Entry
Figure 9.2 Page 178 reveals there are three routes of entry: ingestion, skin contact, and inhalation.

From knowledge of routes of entry for toxic substances it is easy to see the importance of sanitation.

Air Contaminants
Gases easily contaminate the air because air consists of gases, and gases readily mix. The most familiar toxic gas is carbon monoxide.

Vapors are normally liquids or even perhaps solids that release small quantities of gases into the surrounding air.

Mists are tiny droplets of liquids that remain suspended in the air for long periods, as in clouds.
Dusts are recognized as solid particles. Technically speaking, dust particles range in size from 0.1 to 25 micrometers (0.000004 to 0.001 inch) in diameter.

Fumes are also solid particles but are generally too fine to be called dusts. Actually, the sizes for fume particles and dusts overlap, as can be seen in Figure 9.3.

Particulates are a general classification which includes all forms of both solid and liquid air contaminants (i.e., dusts, fumes, and mists).

Threshold limit values (TLV)
The term threshold limit value (TLV) evolved to mean that level of concentration to which the worker could be exposed during the entire workday without significant harm.

The TLV varies drastically with the toxicity of the contaminant, every toxic substance has its own TLV.

For known toxic substances there is a listed TLV, which is a value agreed upon by a committee of the American Conference Of Governmental Industrial Hygienists (ACGLH) and is listed in the "TLV booklet."

The TLVs themselves can change from year to year as more information becomes available.

Permissible Exposure Limits (PEL)
The term Permissible Exposure Limit (PEL) was used to distinguish between the OSHA-prescribed level and the ACGIH term "TLV."

Appendices A.1, A.2, and A.3 display tables of PELs.

Measures Of Exposure

Time-Weighted Averages
The most popular measure of air contaminant exposures is the time-weighted average (TWA) which is computed as a weighted average concentration over an 8-hour shift.

PELs are understood to be TWAs unless otherwise specified.

The PEL recognizes that concentrations of air contaminants change over time and that it is sometimes permissible for a workplace concentration to exceed the threshold limit value (TLV) if at other times during the workday the exposure is sufficiently lower than the TLV, such that the average exposure for the workshift is lower than the specified level.
The formula on page 183 is used to compute the TWA for one substance. We will do lots of exercises using this formula.

The synergistic effect of combinations of toxic substances is a complicated subject. OSHA takes a moderate approach by requiring simple combinations of toxic substances to be considered but generally ignoring the complex synergistic effects. The method is to sum the ratios of concentrations of each substance to its own PEL.

The formula on page 184 summarizes the computation for multiple substances.

**Ceiling Levels and STELs**
Most of the PELs listed in the main table (Appendix A.1) are to be considered TWAs, but for some substances the concern is for short-term exposures. A "ceiling" value, sometimes abbreviated “C” or MAC for maximum acceptable ceiling, is an exposure limit that should never be exceeded.

Short-Term Exposure Limit recognizing the danger of acute exposures, but allowing short excursions above a level that on an 8-hour shift basis would clearly be hazardous. The STEL states a maximum concentration permitted for a specified duration, usually fifteen minutes. For instance, Table A.2 Page 475 lists the following PELs for Toluene.

- **Toluene:**
  - TWA 200 ppm
  - MAC 300 ppm
  - STEL 500 ppm for 10 minutes

**Units of Measure**
Gases are usually more conveniently measured by volume, and thus the first column (Appendix A.1), labeled p/m (parts per million), is usually used for these substances.

Liquids and some solids are more conveniently measured by weight, and thus the second column, labeled mg/m3 (milligrams of particulate per cubic meter), is preferred for these substances.

**Action Levels**
ALs anticipate the problem before TLVs or other measures are exceeded. ALs are set arbitrarily at 1/2 PEL. The difference between the AL and the PEL is that the AL provides a margin for error to ensure that worker exposures do not exceed the PEL, by implementing controls before the PELs are reached.

**Standards Completion Project**
A list of standards completed, along with the associated PEL for each substance covered, appears in Table 9.1. As the table shows, some of these substances are extremely hazardous and no PEL is specified. For these substances, the standard is very specific
regarding procedures to be followed, respirators to be used, and other protective measures.

Detecting Contaminants
Safety and health managers need to have knowledge of the processes within their plants so that they know where to look or at least whom to ask.

Air sampling and testing are the way to determine concentrations as accurately as possible, but before the test is made, some suspicion of possible contamination needs to be provided by other evidence.

The most common way of first detection of a potential problem is by sense of smell.

Carbon Monoxide, Carbon Dioxide, Nitrogen, and Methane are also essentially odorless and can be dangerous simply by displacing the oxygen in the air.

Even Hydrogen Sulfide, a gas that is both dangerous and has a very strong rotten odor, cannot be detected reliably by sense of smell. Table 8.2 provides some information from NIOSH regarding possible contaminants in various industries.

The safety and health manager should not hesitate to involve a chemical engineer in the analysis of potential air contamination’s.

Measurement Strategy
Once an air contamination risk has been determined to exist, a procedure is needed to go about taking samples, measuring employee exposures, and instituting controls. NIOSH recommends a strategy for this purpose, and this strategy is displayed in the form of Decision chart in Figure 9.5 Page 190.

Measurement Instruments
Federal regulation has stimulated the electronics and instrumentation industries to develop new and more precise instruments for determining concentrations.

In the past a canary or a mouse in a cage was often carried into mines. If the canary or mouse died, the workers were alerted to the hazard. A flame safety lamp was used to test for oxygen deficiency; the flame would die if the oxygen proportion in the atmosphere was too low. A brighter-burning lamp was supposed to be an indication of the presence of methane.

There are basically three approaches to measuring air contaminant exposures:

1. Direct-Reading Instruments- are used principally for oxygen deficiency, flammable gases or vapors detection, and certain commonly encountered contaminants.
2. **Sampling with Detector Tubes**- that contain a chemical that reacts to the suspected contaminant if present.

3. **Sampling with Subsequent Laboratory Analysis**- are used for more obscure contaminants and for rarer concentrations. These devices pump a prescribed quantity of air past a filter or sorbent which collects the contaminant, or they merely collect a precise volume of the air itself. The filter, the sorbent, or the air sample is then sent to a laboratory for analysis.

4. **Dosimeters** are the most convenient device of all especially for gathering TWA data. It is a small collector worn on the worker’s body or clothing which collects a time-weighted average exposure over a specified time period.

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Chapter 10  
Environmental Control & Noise

**Ventilation**  
Ventilation is a good way to deal with toxic air contaminants, but it is not the best way. The most desirable way to deal with an air contaminant is to change the process so that the contaminant is no longer produced.

**Design Principles**  
If the process cannot be changed or materials substituted, a well-designed ventilation system may be the best solution to the problem.

OSHA has a standard that deals with this subject, but it must be emphasized that ventilation is a very technical subject, and the safety and health manager may want to turn to a professional engineer to design an adequate ventilation solution to an air contamination problem.

A basic objective of exhaust ventilation is to isolate and remove harmful contaminants from the air. The more these contaminants are concentrated into limited plant areas, the easier they are to separate from the air.

The best exhaust ventilation systems are the "pull" types, not the "push" types.

**Makeup air**  
With an exhaust ventilation system or systems, some source of makeup air is essential. Open windows and doors usually serve this purpose.

Figure 10.3 Page 204 diagrams a recirculating system in which the objective is to remove dust by means of a high-efficiency filter.

There are some other ways around the problem of energy losses due to the introduction of makeup air into the building.
1. Is to introduce the makeup air right at the point at which the contamination is taking place.

2. Is the use of the heat exchanger approach which necessitates passing the makeup air duct close to the exhaust air duct.

**Purification Devices**
The following are some of the basic types of particulate removal devices.

1. Centrifugal Devices - often called cyclones (see Figure 10.5 page 206).

2. Electrostatic Precipitators place a very high (e.g., 50,000 volt) electrical charge on the particles, causing them to be attracted to an electrode of opposite electrical charge (see Figure 10.6).

3. Wet Scrubbers include a wide variety of devices that employ water or chemical solution to wash the air of particulates or other contaminants (see Figure 10.7).

4. Fabric, or Bag-Type Filters are essentially like a vacuum cleaner bag. Some are huge and are located in separate buildings called baghouses. Figure 10.8 shows three types of fabric filters.

**Industrial Noise**

Noise exposure is a classic health problem because of chronic exposure.

Noise has a threshold limit value, and exposures are measured in terms of time-weighted averages.

**Characteristics of Sound Waves**
Noise can be defined as unwanted sound. In the industrial sense, noise usually means excessive sound or harmful sound.

Sound is generally understood as a pressure wave in the atmosphere.

Two basic characteristics of sound waves are:
1. The amplitude, or pressure peak intensity, of the wave
2. The frequency in which the pressure peaks occur

Figure 10-9 illustrates the wave form of sound and also graphs the relationship between pressure and time.

In Figure 10-9 b that *period* is the length of time required for *one* wave to complete its cycle. These periods are always short, too short to count their occurrences while listening to the sound.
The occurrences of wave cycles is called the frequency, usually measured in numbers of cycles per second (called Hertz). A typical sound is at a frequency of 1000 cycles per second—that is, 1000 Hertz (HZ).

Our ears have surprising sensitivity to variations in this frequency count. The sensation is known as pitch. Frequency is important in analyzing the sources of occupational noise exposure.

Decibels
A Decibel (dB) is a unit of measure depicting the sound pressure intensity.

Figure 10-10 relates the decibel to familiar sound levels.

OSHA PELs are expressed in DBAs.

OSHA Noise Standards
Noise is unusual in that it is a hazard for which OSHA has set both a PEL and an AL.

The PEL is set at 90 DBA for an 8-hour TWA. The Action Level (AL) is established at 85 DBA for an 8-hour TWA.

The range of OSHA PELs for noise exposure is given in Table 10.2 Page 215.

Noise Measurement
As a rule of thumb, if you can reach out and touch someone with your thumb but still cannot hear and understand that person's conversation (without his or her shouting), either your hearing is already damaged or defective, or there is excessive noise in the area.

If the noise is no louder than a continuously running vacuum cleaner, there is probably no violation of standards.

If the noise is as loud as fast-moving freight train passing within 20 feet; such a noise level would easily constitute a violation if the exposure were continuous for a full 8-hour shift.

Anything between the vacuum cleaner and the train in sound level would be a gray area which ought to be measured with accurate meters.

A convenient device called a dosimeter, which is worn on the person of the subject under study.

Engineering Control
If noise levels exceed the PEL, federal standards require that feasible engineering or administrative controls be used. If these measures fail to reduce noise exposures to within the PEL, personal protective equipment must be provided and used to reduce sound levels to within the PEL. Engineering controls should be considered a more thorough and permanent solution to the problem.

The logarithmic decibel scale results in a 3DBA change whenever the sound intensity is changed by a factor of 2 (doubled or halved). This leads to a rule of thumb for distance.

“Since sound intensity varies as the square of the distance from the source, a doubling of distance results in a **fourfold** reduction in sound intensity, which in turn reduces the decibel level by 6 DBA.

Case Study 10.4 Page 219.

If spreading out the plant layout is infeasible or too costly, the installation of sound-absorbing barriers between stations can decrease the noise.

Heavy materials absorb sound vibrations, a fact that makes curtains or shields containing lead a popular choice.

More expensive than any of the engineering control approaches discussed so far would be the isolation of the offending machine by means of an enclosure.

**Administrative Controls**
Administratively, management can schedule production runs so that noise levels are split between shifts and individual workers are not subjected to full-shift exposures, interrupt production runs with preventive maintenance to give workers quiet time, and workers can trade jobs at midshift.

The term administrative control is somewhat vague, the term work practices control has become preferable to refer to the various methods of shifting employee exposures to comply with Table 10.2.

**Hearing Protection And Conservation**
Personal protective equipment is required when engineering and administrative controls both fail to reduce noise to legal levels.

Hearing protection is to be *provided* to all employees exposed to the 85-DBA TWA AL.

Employers must permit employees to select protectors from a variety of suitable types and must train employees in the proper use and care of the protectors.

PPE is mandatory when ALs are exceeded, but the actual wearing of the protectors by the workers is not among the mandatory steps to be taken if ALs are exceeded.
Mandatory when:

1. Whenever worker exposures are greater than the PELs (see Table 10.2 Page 215)

2. Whenever worker exposures are greater than the al of 85 DBA (TWA) and the worker has experienced a permanent significant threshold shift

Personal protective equipment should not be considered a final solution because elimination of the source of the noise provides a more satisfactory work environment.

Chapter 11
Flammable And Explosive Materials

In this chapter we examine a more traditional type of hazardous material, flammable and explosive substances, and their employment in factory processes, such as spray finishing areas and dip tanks.

Flammable Liquids

Procedures for storing and handling flammable liquids in an ordinary factory or office environment are different from those where gasoline is manufactured. Therefore, no simple set of rules for flammable liquids is appropriate.

NFPA standard definition of flammable liquid excludes propane and butane by excluding all "liquids" having a vapor pressure in excess of 40 pounds.

Flammable is defined as having a flashpoint below 100 degrees f.

The term flashpoint is very important to the safety and health manager because it is the principal basis for classification of flammable and combustible liquids.

Flashpoint is the point to which a flammable liquid must be heated so that it will give off sufficient vapor to create a flash at the surface of the liquid when there has been a spark or flame applied to it.

Firepoint is a higher temperature and is the temperature at which a fire on top of the liquid is sustained.

Classification of flammable liquids also depends on boiling point; the 10% point is the temperature at which 10% of the liquid has become gas.

Volatile refers to how readily a liquid will evaporate; it is closely related to boiling point. Light and heavy refer to high volatility and low volatility, respectively.

Flammable liquid is a term that means the same thing as Class I Liquid.
Combustible liquid is the general term for both class ii and Class III liquids. The entire classification scheme, which is based on flashpoint and boiling point, is explained in Figure 11.1 on page 231.

Gasoline is the most widely used and plentiful flammable liquid.

Perhaps the wildest myth about gasoline is as follows:

**Flammable Liquid Myth 1**
A lighted cigarette when brought into contact with the surface of a container of gasoline is sure to ignite it.

It is almost impossible to ignite a tank of gasoline at the surface with a lighted cigarette.

Three ingredients are essential to support combustion:
1. Fuel
2. Oxygen (usually from the air)
3. Sufficient heat

See Figure 11.2 Page 232.

The upper limit above which concentrations of flammable vapors are too rich to ignite is designated as the Upper Explosive Limit (UEL). The corresponding lower limit below which concentrations of flammable vapors are too lean to ignite is the Lower Explosive Limit (LEL).

**Flammable Liquid Myth 2**
Fires in the underground gasoline tanks burn or explode with such intensity as to destroy much life and property around service stations.

Fires do not burn in underground tanks of gasoline, even when a serious fire occurs above the ground.

An abandoned empty tank is more dangerous than a full or nearly full tank. The abandoned empty tank has had a chance to dry out, and vapors have gradually dispersed until the mixture may have become lean enough to result in an explosive mixture.

With aboveground tanks the hazard takes on a different dimension when exposed to intense heat it can rupture and explode.

**Flammable Liquid Myth 3**
High-octane "aviation gasoline" or "premium gasoline" is much more hazardous than regular gasoline.
Octane rating has nothing to do with fire safety.

Sources Of Ignition

• a hot light bulb filament
• welding sparks
• sparks generated when grinding
• electrical arcing or static electrical discharges

Figure 11.3 Page 235 When dispensing Class I liquids into metal containers there should be an electrical interconnection between nozzle and container to prevent buildup of static electricity.

To prevent buildup of static electricity during loading operations, the flow should be kept as quiet and smooth as possible because splash loading creates a problem with static electricity. See Figure 11.4 page 235.

Filters are big static generators and are best placed as far back in the line as possible, remote from the fill spout.

Standards Compliance

Federal codes for tank storage are mostly the concern of layout designers of petroleum tank farms, bulk plants, dikes and drainage schemes, refineries, and service stations.

The codes also cover such elements of design as tank construction and proper venting.

Two types of storage tanks: (a) floating roof type; (b) conventional vented type (see Figure 11.6 Page 236).

The floating roof rises and falls with the level of the liquid inside the tank, eliminating the necessity of costly and dangerous venting.

A fixed roof is more hazardous than for the floating roof tank, which has little or no vapor/air space. The floating roof tank is a dramatic example of an industrial improvement that saves production cost while promoting a safer workplace.

Appropriate safety standards require accurate inventory records for Class I liquid storage tanks, especially those that are underground. Underground tanks can leak and contaminate surrounding ground water. Therefore OSHA requires organizations with underground tanks to keep accurate inventory records. Suppose you were the manager of a distribution center and had underground fuel tanks. OSHA would inspect your records of receipts of bulk fuels and your issuance of fuel to your vehicles. Any discrepancy (i.e. 1000 gals in 990 gallon out) must be investigated and reconciled.
With respect to the hazards of leaking tanks, the safety and health manager must follow the regulations of two federal agencies: OSHA and EPA. Case Study 11.1 on page 237.

Combustible Liquids

There is a distinction between flammable liquids and combustible liquids, as shown in Figure 11.1 Page 231. The flashpoints of combustible liquids are higher, and the hazard of ignition is much lower than for flammable liquids.

Another hazard with combustible liquids occurs when switch loading. Switch loading is a danger from the standpoint of ignition by static electricity.

The real danger is when fuel oil is loaded into a compartment that previously contained gasoline.

Remedies for the problem are:
1. fill the tank with carbon dioxide
2. use vacuum cleaners to purge the tank of gasoline
3. cut the loading speed down to about 30% until the tank is about one-third full.

Case Study 11.2 flammable versus combustible liquids (Page 238)

Spray Finishing

There are both health and safety considerations in spray finishing operations.

The standards for spray finishing principally concern safety concerning fire.

The most frequent violations are in the following categories:
• improper wiring type for hazardous location
• exhaust air filter deficiencies
• cleaning and residue disposal
• quantities of materials in storage
• grounding of containers
• "no smoking" signs

Also frequently violated are the physical construction requirements for spray booths and the mechanical ventilation requirements.
• no smoking signs
• use of Class I, Division 2, wiring in all directions from the open face of the spray area or booth,
• control of overspray residues

Dip tanks
Dip tanks often contain hazardous materials and are treated separately in federal standards.

The following are the principal problems with dip tanks:

- automatic extinguishing facilities
- no smoking signs
- dip tank covers

The lack of dip tank covers is the most frequent violation of the three.

Automatically closing dip tank covers are a good idea.

Explosives

Most facilities do not use explosives but those that do have explosives within their facilities should take the precaution of assuring that handling and especially storage procedures are in compliance with applicable code.

Liquefied Petroleum Gas

LPG is principally a mixture of propane and butane, both of which can be liquefied more easily than methane and therefore can be transported more compactly. The expansion ratio is approximately 1:270.

A common hazard with propane is that the extreme cold of its liquid state can burn the flesh. The same as for third-degree burns.

The principal hazard with LPG is fire, and when an LPG fire occurs, it is usually a disaster.

The federal standard requiring the use of laboratory-approved equipment ("listed" by an approved testing laboratory) seems like so much red tape. Some people have used: old hot water tank for storage, used ordinary water hose and plumbing fittings and valves which have rubber seals instead of approved piping.

Fire, welding operations, and other sources of intense heat can weaken LPG cylinders and make them no longer capable of meeting laboratory tests.

With any high-pressure cylinder should the valve accidentally rupture or break off it will act like a torpedo.

Chapter 12
Personal Protection and First Aid

Hearing Protection
If engineering or administrative control measures are unsuccessful in eliminating the hazard of noise in the workplace, management must turn to personal protective equipment to shield the worker from exposure.

The most important factor in selection of the type of noise protection is probably effectiveness in reducing decibel level of noise exposure.

**Cotton balls**
Ordinary cotton balls are virtually worthless.

**Swedish wool**
Is somewhat effective but is much more effective when impregnated with wax to make a better seal.

**Earplugs**
The most popular type of personal protection for hearing is the inexpensive rubber, plastic, or foam earplug.

**Molded ear caps**
May be more comfortable to the wearer, but are more expensive than earplugs.

**Earmuffs**
Are larger, generally more expensive, and more conspicuous than Swedish wool, plugs, or caps, but they can have considerably better attenuation properties.

**Helmets**
Used for the most severe noise exposure problems. Helmets are capable not only of sealing the ear from noise, but also of shielding the skull bone structure from sound vibrations.

It must be remembered that fit is very important for all types of hearing protectors. As in noise enclosures or sound barriers, the material itself might have excellent sound attenuation properties, but if there is a leak or crack, most of the effectiveness of the device is lost.

### Eye and Face Protection

There is a difference between street safety glasses and industrial safety glasses. Industrial safety lenses must pass much more severe tests to meet ANSI standards.

Safety and health managers say that a simple plant-wide rule is easiest to enforce.

Some jobs for which there is a need for eye protection:
- Machining operations that produce chips or sparks. I.e. grinding, and drilling
Both metal and wood materials can produce dangerous eye hazards when machined.

Full face protection may be needed in addition to eye protection when using corrosive liquids or other dangerous chemicals.

See Table 12.1 on page 253.

Education of the workforce is also important to be alert for eye hazards and the long-term consequences of eye injury.

Respiratory Protection

There is more to respiratory protection than simply handing out respirators to workers who might be exposed to hazards.

Effective protection demands that a well-planned program be implemented, including proper selection of the respirators, fit testing, regular maintenance, and employee training.

Bad habits, such as negligent maintenance, inadequate fit testing, or improper equipment usage, can develop.

The two major classifications are (1) air-purifying devices and (2) atmosphere-supplying devices.

The air-purifying devices are generally cheaper, less cumbersome to operate, and the best alternative if they are capable of handling the particular agent to which the user will be exposed.

But another important consideration is oxygen deficiency. The only way to go in this situation is with atmosphere-supplying respirators.

A summary classification of respiratory protection devices:

1. Air-purifying devices
   A. Dust mask
   B. Quarter mask
   C. Half mask
   D. Full-face mask
   E. Gas mask
   F. Mouthpiece respirator

2. Atmosphere-supplying respirators (used when entering a confined space)
   A. Air line respirator
   B. Hose mask
C. Self-contained breathing apparatus

Air-Purifying Devices

1a. Dust mask (Figure 12.2) is the most popular because it is inexpensive, sanitary, and can be thrown away after each use, and is the most misused. Approved only for particulates (suspended solids), not for painting and welding hazards. Even the best-fitting models have approximately 20% leakage.

1b. Quarter mask (Figure 12.3) sometimes called the type b half mask because it looks very much like a half mask except that the chin does not go inside the mask.

1c. Half mask (Figure 12.4) fits underneath the chin and to the bridge of the nose, has four suspension points; two on each side of the mask and connected to rubber or elastic about the head.

1d. Full-face mask (Figure 12.5) refers to a mask in which the filtering chamber attaches directly to the chin area of the mask. The filters may be either dual cartridges or single canisters.

1e. Gas mask (Figure 12.6) is designed for filtering canisters that are too large or too heavy to hang directly from the chin therefore it is suspended by its own harness and connected by a corrugated flexible breathing tube.

Atmosphere-Supplying Respirators

2a. Air line respirator is an atmosphere-supplying respirator that supplies air to the mask by a small-diameter hose (not over 300 feet long). Three types: the continuous-flow, the demand-flow, and the pressure-demand flow.

2b. Hose mask is a somewhat crude form of an air line respirator. The diameter of the hose is larger than in the air line respirator, permitting air to be inhaled by ordinary lung power. A blower is sometimes used as an assist.

2c. Self-Contained Breathing Apparatus (SCBA) the user carries all of the apparatus with him, usually on his back.

Case Study 12.1 Page 259.

There exists an OSHA standard for confined space entry.

Respirator Plan

Adequate planning for respirators and their appropriate use, maintenance, and the training of employees who will wear them is an important OSHA requirement.

Consultants can help to select between approved respirators, considering efficiency, cost, convenience, and other factors.
Be sure that persons are "physically able to perform the work and use the equipment.

A variety of physical conditions can make a person unfit for respirator use. Conditions include: asthma or emphysema, back injury or heart disease, ruptured eardrum, epileptics, diabetics, and some psychological factors.

An important element is fit testing or leak testing. Facial characteristics vary significantly making fit tests necessary; beards should be prohibited.

Routine inspections before and after each use can be performed by the users for cleanliness, deterioration, and obvious function.

Self-contained breathing apparatus should have an effective monthly inspection.

Confined Space Entry

One of the most dangerous jobs in industry is cleaning, repair, or maintenance that requires entry inside a tank or other confined space.

Case Study 12.2 Page 265

Identifying the Hazard
The principal hazard is the atmosphere inside the space, but some confined spaces represent a mechanical hazard, such as descending into an ever-tightening constricting space. I.e. silos, tapered storage bins, hopper-feeders, and cyclone collectors.

Another hazard is engulfment, sand, grain, and other granular dry solid material can have fluid-like properties.

Case Study 12.3 Page 265

Although engulfment is a serious hazard, simple oxygen deficiency (less than 19.5% oxygen in breathing air) is the biggest killer in confined spaces.

Too little oxygen is a hazard, but so is too much. Oxygen has density slightly heavier than normal breathing air, so oxygen enrichment (oxygen content greater than 23.5%) can enhance the possibility of fires being generated when wielding on burning.

Head Protection

Hardhat rules should be carefully formulated with ample consideration for the hazard at hand. Once it has been decided that a hardhat rule is necessary, the safety and health manager should take steps to ensure its implementation.
Miscellaneous Personal Protective Equipment

Safety shoes are clearly needed on and around shipping and receiving docks.

Protective Clothing And Skin Hazards
Occupational skin disease represents approximately 70% of all occupational diseases, and over 80% of the skin disease reported is classified as contact dermatitis from irritants to the skin.

Gloves must be impervious to the liquid being handled and must be long enough to prevent the liquid from getting inside, i.e. around dip tanks.

The most common hazard among skin irritants are the cutting oils used in metal machining operations.

Cutting oils are basically of two types: natural and synthetic.

Natural oils are petroleum based and are the chief culprits in oil folliculitis.

Synthetic oils generally are milky white appearance, not likely to cause oil folliculitis but may become contaminated with bacteria thus presenting the hazard of skin infections. Creams may help.

Solvents are essential for removal of grease and cutting oils, it is bad practice for workers to wash piece parts in trichloroethylene with their bare hands, gloves are in order or substituting soap and water.

Workers who are fastidious about washing their hands and bodies have frequently been found to enjoy a lower incidence of skin disease.

First Aid

The first-aid station may satisfy several functions besides providing immediate care for the injured, it is often used for medical tests, screening examinations, and monitoring of acute and chronic effects of health hazards.

The plant nurse or other first-aid personnel may be responsible for performing some of the recordkeeping and reporting functions.

A first-aid kit or first-aid supplies should be on hand. In addition there should be a provision of emergency showers and emergency eyewash stations where injurious corrosive material exposure is a possibility.

Chapter 13
Fire Protection
The field of industrial fire protection includes such alternatives as emergency action plans, fire prevention, fire brigades, fire alarm signaling systems, fixed extinguishing systems, and automatic sprinkler systems.

Fire protection does not mean only fire extinguishment, but it really encompasses three fields (or strategies): fire prevention, fire suppression, and personal protection (escape).

Industrial Fires

According to the national safety council, fire is the fifth leading cause of accidental death. The United States has one of the worst fire death rates in the industrial world, about 20 deaths per million people.

The vast majority of fire deaths in the United States are in residential occupancies.

The most dangerous five (5) industries from a fire hazard standpoint are mines, grain elevators, grain mills, refineries, and chemical plants. The fire fatalities from these five industries dwarf the total for all remaining industries combined.

For general manufacturing industries the number of fire fatalities is extremely low.

The triangle shirtwaist fire had a profound impact on regulations to control industrial fires in the United States.

Strategy #1- Fire Prevention

The best way to deal with fires is to prevent their occurrence using engineering controls as the preferable method to personal protective equipment.

A principal cause of industrial fires is overheated bearings or hot machinery and processes.

In addition clogged or dirty ventilation filters or ducts, especially with flammable or combustible air contaminants are also a prime source of fires. These causes can be averted by adopting an effective preventive maintenance program.

Housekeeping; the accumulation of paper and material waste, combustible dusts and paint residues are good examples of how poor housekeeping can contribute to fire hazards.

Strategy #2- Emergency Evacuation (Personal Protection)

The employer must prepare a written emergency action plan.

Alarm Systems
Questions that must be answered include: will persons recognize the signal as a fire alarm? And what about deaf or blind employees? Will audible, visual, and tactile systems must be utilized? Case Study 13.1 on page 278.

System reliability - some systems have built-in monitor circuits to supervise reliability which do not need testing as often as do simple alarm systems.

Backup systems provide continuous protection when repairs are being made or when power outages occur. These may employ "runners" or telephones or other informal systems but they need to be documented.

Fire Detection Systems
Smoke alarms and other detection devices such as manual or visual systems may be used to trigger the alarm system. They are not mandatory.

Strategy #3 - Fire Suppression

A. Fire brigades
Some firms may elect to organize employees into fire brigades to fight fires themselves. Such strategies should be carefully scrutinized because in the scramble to protect property, these fire brigades can be a danger to employees. Concerns include:

1. Employee fitness
2. Firefighter training - training should occur quarterly or annually and equipment inspected annually.
3. Protective clothing and apparatus

B. Fire Extinguishers
Still the most effective method of immediately controlling a local fire. The various fire classes and the type of extinguishers are discussed in this section.

Fire Classes
The four classes are described in Table 13.1 Page 279 along with sample appropriate extinguisher media, and the maximum travel distance specified for extinguishers for each type.

What determines class? Know!!

Some types of extinguishers are approved for more than one class, to determine whether an extinguisher is appropriate for a given class of fire hazard check the approval marking on the extinguisher.

Table 13.2 Page 280 describes some forbidden types of extinguishers.
Inspection, Testing, And Mounting
OSHA has abandoned the rule requiring tags on each extinguisher, but still requires the employer to maintain records of maintenance for each extinguisher.

Visual inspections are required monthly and detailed inspections are required annually.

The safety and health manager should leave the testing to processional fire extinguisher service personnel.

The current performance standard permits the employer some latitude as to mounting extinguishers on the wall, out of the way of forklift truck traffic, and yet accessible without subjecting employees to possible injury.

Training and education
Few employees know how to use a fire extinguisher effectively therefore training is required upon initial employment and at least annually thereafter.

C. Standpipe And Hose Systems

Equipment
Examples of modern systems:
1. Shutoff-type nozzles
2. Lining for hose
3. Dynamic pressure minimums at the nozzle
4. Hydrostatic testing upon installation

The supply must be sufficient to provide 100 gallons per minute flow for at least 30 minutes (3000 gallons per use period).

Some organizations connect hose systems to city water supplies which usually cannot meet the 100-gallon-per-minute flow requirement.

Maintenance
Hemp and linen systems are subject to deterioration. Hose systems should be checked annually and after each use. In the case of hemp or linen hose systems, the hose must be re-racked using a different fold pattern.

D. Automatic Sprinkler Systems

If a spray area is protected by an automatic sprinkler system, a good way to protect the sprinkler heads is to cover them with paper bags.

If material is stacked too close to the ceiling this interferes with the distribution of spray from the sprinkler head. (Figure 13.1) minimum vertical clearance between stacked material and sprinkler head is 18 inches.
E. Fixed Extinguishing Systems

A fixed extinguishing system is a local system for controlling special fire hazards such as kitchen grills or tempering tanks to prevent destruction of property.

If a strategy of "total flooding" is used with a dangerous agent, an emergency action plan is necessary to assure that personnel escape. Some agents are so dangerous as to be prohibited altogether as extinguishing media; examples are chlorobromomethane and carbon tetrachloride.

Fixed extinguishing systems are required to be inspected annually.

**Dry Chemical Systems**  
Dry chemicals used for extinguishing agents are usually not dangerous to the health or safety of personnel.

The biggest problem occurs in humid climates or moisture-producing processes which can cause the dry chemicals to cake or lump. Either of which can render the dry chemical system useless, it should be sampled annually.

**Other Fixed Systems Agents**  
Employ carbon dioxide, halon 1211, or halon 1301 gases. These gases can be dangerous to unsuspecting employees, especially if a total flooding strategy is employed. Standards must be followed in planning predischARGE warning systems, employee egress routes, and maximum concentrations of gases to be released.

Chapter 14  
Materials Handling And Storage

Lifting accounts for most back injuries, the largest workplace injury category of all.

The National Safety Council (NSC) charges materials handling with 20 to 25% of all occupational injuries.

As an average, industry moves about 50 tons of material for each ton of product produced. Some industries move 180 tons for each ton of product.

**Materials Storage**

Housekeeping is an important consideration for materials in storage. Sloppy warehouse practices can lead to trip hazards or fire, i.e. spillage leads to pest harborage and outside storage area overgrown with weeds.
The safety and health manager should monitor the changes in the company's sales and production forecasts. Because existing warehouse space can become crowded and unsafe, resulting in material stacking procedures being discarded, and aisle and exit blockage will occur.

**Industrial Trucks**
Forklifts are typically either electric motor powered or have internal combustion engines. Other equipment includes: tractors, platform lift trucks, motorized hand trucks, and specialized equipment.

**Truck Selection**
It is complicated to select a forklift truck. Because engines and motors can be dangerous sources of ignition for flammable vapors, dusts, and fibers.

Industry standards for industrial truck classifications are contained in Table 14.1 Page 290.

Table 14.2 Page 290 provides the safety and health manager a perspective into the approval classes of various industrial truck designs. The classes, groups, and divisions correspond roughly to those of the national electrical code.

Class and group refer to the type of hazardous material present, and division refers to the extent or degree to which the hazardous material is likely to be present in dangerous quantities.

**Operations**
Of interest to the safety and health manager should be the refueling or recharging area of forklifts.

Smoking is prohibited in these areas, and is cited more than any other. Also a problem is the charging of forklifts in a nondesignated area.

Hazards include spilled battery acid, fires, lifting of heavy batteries, damage to the equipment by the forklifts, and battery gases or fumes.

Arcs and sparks frequently fly when battery connections are made and that gases liberated during charging processes can reach ignitable concentrations.

Ventilation, personal protective equipment and emergency eyewash and shower should be provided in the battery charging area.

Diesel, gasoline, and LP gas engines—emit carbon monoxide, a dangerous gas.

If it is determined that carbon monoxide exists in the plant and that the forklift trucks are the culprit, several alternatives are possible:
1. Switch to electric forklifts
2. Alter the building or to install adequate ventilation systems
3. Review operational procedures to determine whether sources of emissions can be reduced or perhaps eliminated.

The following are key questions:
1. Are operators leaving engines running unnecessarily?
2. Can the layout of warehouses or plant facilities be revised to reduce concentrations?
3. Are faulty or worn-out lift trucks creating more emissions than necessary?

If general lighting requirements are low for an area (less than 2 lumens per square foot), fork trucks must have directional lights.

Forklift Driver Training
Because workers know how to drive an automobile, they also think they know how to operate a lift truck. However there are some differences:
1. Lift truck has a much shorter wheelbase
2. Its center of gravity is very high
3. The wheels are small in diameter
4. Picking up and depositing loads requires skill
5. Off-center load presents a special hazard
6. Visibility problems
7. Passengers and hitchhikers

One of the greatest hazards with forklifts and other industrial trucks is the transition between dock and cargo vehicle. Figure 14.2 Page 294.

Passengers
Using the forklift truck as a personnel elevator can be safe if:
1. A safety platform is firmly secured to the lifting fork.
2. The person on the platform can shut off power to the truck.
3. Protection from falling objects is provided if needed.

Wood pallets are not considered to be a safety platform

The forklift driver should receive special training for industrial trucks.

Equipment dealer representatives can be of assistance.
Parking and Maintenance

Parked and unattended forklifts are a problem. The first thing to do is determine if the forklift is unattended. OSHA defines an unattended forklift as:

(a) can the operator see the truck? If not it should be considered unattended.
(b) if he can see the truck, is he more than 25 feet away? If so it should be considered unattended.
(c) It should be considered unattended if the motor turned off.
(d) If the operator is close by are the forks fully lowered and the controls neutralized?

Additional Criteria:

(e) is the brake is set
(f) if on an incline, are the wheels blocked
(g) does the horn work

Federal standards take very seriously the question of maintenance, inspection, and service for industrial trucks. An inoperative horn, defective brake, or broken headlight are causes to remove it from use until repaired.

Federal standards require industrial trucks in use to be inspected for safety daily (after every shift).

The overhead guard’s function is to protect the operator from falling objects such as small packages, boxes, and bagged material, not for protection against the impact of a full capacity load.

Are not to be used as Rollover Protective Structures (ROPS).

Cranes

Cranes, called overhead bridge cranes or simply bridge cranes, in industrial plants are generally limited in travel by a track or overhead runway structure, typified by the overhead traveling crane shown in Figure 14.3 Page 297.

The chief concern with overhead cranes is overload. Therefore the rated load should be plainly marked on each side of the crane.

The actual weight of the load, dynamic loads during transport, shock loads during lifting, variations in crane components, and unavoidable design variabilities can combine to result in a very dangerous situation even when rated load capacities are "slightly" or "occasionally exceeded.

Outdoors wind can be a hazard therefore automatic rail clamps are required.

A critical hazard to the wire rope of a crane or hoist can result from drawing the load hook or hook block up too far... Known as two-blocking.
Construction standards now address this hazard, and electromechanical devices are on the market for the purpose of preventing it to happen.

Electric shock is a concern with overhead cranes:

- shock from exposure to current-carrying portions of the crane's power delivery system
- shock from a shorted connection in a hanging control pendant box (see Figure 14.4 Page 300)
- accidental contact of live, high-voltage overhead transmission lines

One hazard to think about with overhead cranes is what would happen if a temporary power failure occurred.

Another occurs when the power is restored. A disconnect device can neutralize all motors and not permit a reconnect until some sort of positive "reset" action is taken.

Crane Inspections
The standards use the terms “frequent” or “periodic” to specify when various items on the crane should be checked.

The frequent-inspection routine should include a daily visual inspection of hoist chains, plus a monthly inspection with a signed report.

Crane hooks take a great deal of abuse and are critical to the safe operation of the crane. Telltale signs of an abused and dangerous hook are illustrated in Figure 14.10 Page 307.

The safety of an overhead crane is in part a function of the installation method and proper adjustments at the site. Standards require an actual rated load test prior to its initial use that is 25% higher than the crane's load rating.

Wire Rope Wear
The two principal moving parts of an overhead crane are the wire rope and the drum and sheaves upon which they travel.

A means of evaluating the degree of wire rope deterioration is awkward and difficult but necessary to prevent catastrophic failure.

The ANSI standard recommends a procedure for counting the broken wires. Figure 14.11 Page 309 diagrams the components of wire rope, defining the terms strand and lay. If there are more than 12 randomly distributed broken wires in a single strand in a single lay, there should be cause for questioning the continued use of the rope.
Another measure of deterioration is the amount of reduction of rope diameter below nominal. Figure 14.12 Page 309 shows that the proper terminology is to use the larger diameter for designation as the nominal diameter of the rope.

**Operations**
The operator of the crane is probably the most important factor in preventing accidents; skill is required to hook-up, etc.

**Slings**
Slings are used to attach the load to the crane, helicopter, or other lifting device.

The stress on a sling is greatly dependent on the way it is attached to the load. Figure 14.13 Page 310 shows two different ways of applying a sling to pick up identical loads.

Selection of the proper sling for a given application can consider several factors: rated load, nature of the item to be lifted, its surface finish, temperature, sling cost, and environmental factors.

Table 14.3 Page 312 is intended to summarize some of the more curious differences between requirements for various types of slings.

**Conveyors**

Some of the worst conveyor hazards are very innocent in appearance. In-running nip points can start an irreversible process resulting in an employee's entire body being drawn into a machine because of loose clothing getting caught.

**Belt conveyors**
On a belt conveyor, one side of every pulley is always an in-running nip point. Defense against this hazard generally consists of one of three means: isolating the nip points, installing guards, and installing emergency tripping devices.

The best method of protection is to isolate the in-running nip point so that an employee would not or could not come into the danger area.

If isolation is impractical, a guard can sometimes be installed to keep out the worker’s body or extremities.

**Overhead conveyors**
Overhead conveyors avoid many of the risks of belt conveyors by eliminating many of the in-running nip points by removing the moving parts from worker access.

But hazards such as falling materials exist. Screens or guards can protect against this hazard but not entirely. A good rule is to place screens or shields under the conveyor...
whenever it passes over an aisle or other area where personnel are likely to gather and
where the conveyor chain moves up or down an incline.

Figure 14.14 Page 314 shows three different orientations for the hangers or hooks that
support the work held by an overhead conveyor.

Screw conveyors
Screw conveyors can be very dangerous because the intake must be completely
submerged in the material which also means that an unseen serious hazard at the intake is
hidden.

A simple and often effective way to protect workers from the hazards of the screw intake
is to box the intake area in a small screen enclosure which allows passage of the material
but keeps out fingers, hands, and feet.

Lifting

As stated earlier in the text back injury, mostly from lifting, is one of the biggest
compensable injury categories of all. Therefore much emphasis has been placed on
technique, with the most frequently heard saying being, "lift with your legs, not with your
back." Training and exercise with light loads can help in developing the technique, but
there are disadvantages of this technique.

Chapter 15
Machine Guarding

The safety and health manager should take a leadership role in the implementation of
machine guards identifying problem areas, setting priorities, selecting safeguarding
alternatives, and ensuring compliance with standards.

General Machine Guarding

Safety and health managers need to be knowledgeable about what makes a machine
dangerous.

Mechanical hazards
Following are general machine mechanical hazards listed in approximate order of
importance.

1. Point of operation
2. Power transmission
3. In-running nip points
4. Rotating or reciprocating machine parts
5. Flying chips, sparks, or parts
By far the largest number of injuries from machines occur at the point of operation, where the tool engages the work.

The second most important is the general machine hazard, the power transmission apparatus of the machine, typically belts and pulleys.

Machines that feed themselves from continuous stock generate a hazard where the moving material passes adjacent to or in contact with machine parts.

This hazard is called an in-running nip point or an ingoing nip point. Figure 15.1 Page 322 shows examples of in-running nip points which can cause injury or catch loose clothing and pull the worker into the machine.

Rotating or reciprocating moving parts can present worker hazards as well.

Machines that move intermittently (remain motionless part of the cycle) can also create hazards; material-handling apparatus, clamps, and positioners are in this category.

The most intermittent motion of all is accidental motion. It pays to consider what would happen in event of a hydraulic failure, broken cotter pin, loosened nut, or some other accidental occurrence. Would the guard on the machine protect workers in these circumstances? Is the risk of occurrence of enough significance to warrant installing a guard?

Many machines throw off chips or sparks. One means of protecting workers from flying chips and sparks is by personal protective equipment. But this is not nearly as effective as using machine guards

**Guarding By Location Or Distance**

The easiest and cleverest way to guard a machine is not to use any physical guard at all but rather to design the machine or operation so as to position the dangerous parts where no one will be exposed to the danger.

Guarding "by distance" refers to the protection of the operator from the danger zone by setting up the operation sequence such that the operator does not need to get close to the danger (see Figure 15.2 Page 323).

**Tagouts and Lockouts**

A surprising number of industrial machine accidents occur not when the machine is in operation, but when it is down for repair (Case Study 15.1 Page 324).

Two simple safety procedures are the tagout system and the lockout system.

The tagout system is a simple system that involves the use of a “tag” clipped on to the on-off switch or control box.
The lockout system (see Figure 15.3 Page 325) utilizes locks for which the maintenance person is the only one with a key.

Lockout/tagout became one of the most frequently violated standards nationwide. The worst problems encountered were failure on the part of employers to establish a lockout/tagout program in the first place, the failure of employers to train employees properly to observe the lockout/tagout procedures, and failure to document the procedures.

**Zero Mechanical State**
The hazards of stored energy in machines, even when they have been turned off, have led to a safety concept known as zero mechanical state.

Machines can quietly hold dangerous energy even when they are turned off. Various forms of energy can be stored, such as pneumatic or hydraulic pressure, electrically charged capacitors, spring tension or compression, or kinetic energy from flywheel rotation.

**Interlocks**
The use of interlock devices are what cause clothes dryers to stop rotation as soon as the door is opened, and thus comply with industry safety standards for revolving drums, barrels, and containers.

**Trip bars**
Trip bars stop the machine if the operator falls into or trespasses into the danger zone (Figure 15.4 Page 327).

An alternative is to provide a tripod or tripwire (Figure 15.5 Page 327).

**Fan blade guards**
OSHA safety standard requires that fan blades have guards whose openings do not exceed 1/2 inch (Figure 15.6 Page 328).

**Anchoring machines**
Anchoring fixed machinery is required for all machines designed for a fixed location. Machines that have reciprocating motions, such as presses, have a tendency to "walk" unless securely anchored.

**Safeguarding the Point Of Operation**
The point of operation is the most dangerous part of machines in general, so dangerous that some type of safeguarding is required for every setup, i.e. mechanical power presses. Figure 15.7 on page 330 presents many devices that are helpful in eliminating the need for an operator to put his hand into the danger zone.
A general classification of the methods used to safeguard the point of operation is guards and devices:

1. Guards
   A. Die enclosures
   B. Fixed barriers
   C. Interlocked barriers
   D. Adjustable barriers

2. Devices
   A. Gates
   B. Presence-sensing devices
   C. Pull-outs
   D. Sweeps (no longer accepted for mechanical power presses)
   E. Hold-outs
   F. Two-hand controls
   G. Two-hand trips

1. Guards
The function of a guard is to keep the worker out of the danger area. However, too many workers will defeat the purpose of the guard by reaching through, over, under, or around the guard, exposing themselves to perhaps a greater hazard.

One principle of machine guarding is the maximum permissible opening size.

If the guard is immediately adjacent to the danger zone, no opening should be large enough to permit a finger to reach through. The principle behind the standard openings is illustrated in Figure 15.8 Page 332.

Fixed barriers
Fixed barrier guard is a general term for a wide variety of guards that can be attached to the frame of the machine (Figure 15.10 and Figure 15.11 on Page 333).

Interlocked barriers
An interlock, typically electrical, disables the actuating mechanism whenever the guard is opened (Figure 15.12 Page 333).

Awareness barriers
An awareness barrier (see Figure 15.14 and Figure 15.15 on Page 335) is not recognized as a guard and does not meet the guarding criteria of keeping the operator's hands or fingers out of the danger zone.

When the fingers are too close to danger they lift a barrier.

Power Presses
Press hazards
One of the biggest causes of accidents with power presses is an attempt on the part of the operator to readjust a misaligned workpiece in the die.

Because of this the standards writers initiated a policy of "no hands in the dies." The theory was that tongs or other tools and devices could be used to feed workpieces, eliminating the need for the worker to put his or her hands into the danger zone.

Point-Of-Operation Safeguarding
Safeguarding methods can be divided into four categories, ranked according to degree of security:

1. Methods that prohibit the operator from reaching into the danger zone altogether
2. Methods that prohibit the operator from reaching into the danger zone any time the ram is in motion
3. Methods that prohibit the operator from reaching into the danger zone only while the dies are closing
4. Methods that do not prohibit the operator from reaching into the danger zone but that stop the ram before the operator can reach in

Press Guards
With only one exception, a guard or some type of point-of-operation safeguarding device must be installed on every mechanical power press.

Gates
Gates look like a guard (see Figure 15.20 Page 342) but they are different in that they open and close with every machine cycle.

Two types of gates: type A and type B.

1. The type a gate is the safer of the two because it closes before the press stroke is initiated.
2. Type b gates remain closed only long enough to prevent the operator from reaching in during the more dangerous downward stroke.

Presence-sensing devices
One type uses a bank of photoelectric cells to set up a light screen, the penetration of which will immediately stop the ram. Figure 15.21 and Figure 15.22 on Page 343 illustrates this type of device.
It becomes a game for workers to defeat these devices. Some workers aim flashlights or other sources of light to maintain the sensors in an energized condition. Sometimes ordinary ambient light in the factory may keep sensors energized.

The infrared frequencies rather than in the visible light spectrum may have some advantages.

Presence-sensing device sometimes uses a conductor to set up an electro-magnetic field in its vicinity. Figure 15.23 Page 344 illustrates the electromagnetic field type of presence-sensing device.

**Pullbacks**  
Are cables mechanically linked to the travel of the ram and attached to wristlets which pull the operator's hands out of the danger area as the ram makes its downward stroke. Figure 15.24 and 15.25 on Page 346.

Safety standards require an inspection for proper adjustment at the start of each operator shift, following a new die setup, and when operators are changed.

**Sweeps**  
Sweeps are no longer recognized as adequate point-of-operation safeguarding device on mechanical power presses. (Figure 15.26 Page 347)

**Hold-outs**  
Hold-outs look almost exactly like pullbacks (Figure 15.27 Page 347), but the big difference is that the hold-out reach is fixed and does not permit the operator to reach in at all, even between strokes of the machine.

**Two-hand controls**  
Require both hands to operate the controls, or so the theory goes (Figure 15.28 Page 349) illustrates a two-hand control device and some of the features that attempt to prevent the worker from defeating the device. The machine will stop if released.

There is a nice summary of all safeguard mechanisms in Table 15.1 on Page 354.

**Grinding Machines**

Grinding machines are in almost every manufacturing plant—on the production line, or in a toolroom, or maintenance shop.

There are two or three items which create the most trouble as follows (shown in Figure 15.32 Page 355):

1. Failure to keep the workrest in close adjustment (within 1/8 inch) to the wheel on off-hand grinding machines
2. Failure to keep the tongue guard adjusted to within 1/4 inch
3. Failure to guard the wheel sufficiently

A severe stress can be placed on the grinding wheel if the workpiece becomes wedged between the workrest and the wheel (Figure 15.33 Page 356).

Workers need to check the gap adjustment on the grinding machine workrest as illustrated in Figure 15.34 Page 356.

Saws
Almost everyone respects the danger of a power saw, but serious injuries continue to occur.

Radial saws
Radial saws or radial arm saws can be quite dangerous (Figure 15.35 Page 357 no lower guard) Figure 15.36 Page 358 illustrates one type of lower blade guard for radial arm saws. The guards are very unpopular and are often removed by employees.

Another problem with radial saws is the return-to-home position. The saw should be mounted such that "the front end of the unit will be slightly higher than the rear, so as to cause the cutting head to return gently to the starting position when released by the operator.

Table saws
Table saw is an everyday term for a hand-fed saw with a circular blade mounted in a Table. Unlike the radial saw, the Table saw head always remains stationary during a cut while the work is fed into it. With Table saws, the three biggest problem areas are hood guards, spreaders, and nonkickback fingers (see Figure 15.37 Page 359).

Antikickback protection is more important for ripsaws than for crosscut saws.

The hood guards present the most problems because the obstructed view makes the saw operator's job more difficult and awkward.

Kickback
Kickback is the word used to describe the situation in which the entire workpiece is picked up and thrown back at the saw operator.

Both the spreader and the nonkickback fingers are intended to help prevent kickback.

The spreader keeps the saw kerf open or spread apart in the completed portion of the cut so that the material will not contact the blade.

The nonkickback fingers, or "dogs," are designed to arrest the kickback motion should it start to occur.
Band saws
A sliding guard is used for protection and is moved up or down to accommodate larger or smaller workpieces.

Hand-held saws
Proper training and operator respect for the saw are important, as are a clean, sharp blade, a "dead-man" control, and a retractable guard for the lower portion of the blade.

Reverse polarity brakes can be installed on saws, which caused the blade to come to an immediate halt as soon as the operator releases the trigger.

Chain saws
Is the most hazardous hand-held saw.

Belts And Pulleys

Belts and pulleys represent a good target area for the safety and health manager to institute a low-cost program of in-house safety improvement.

Figure 15.39 Page 363 displays a decision chart used to identify which type of guard is required.

A height of less than 7 feet off the floor or working platform is generally considered a working zone where personnel need protection from belts and other machine hazards.

The preferred method of eliminating hazards with shaft couplings (typically found between a pump and the motor) is to design them such that any bolts, nuts, and setscrews are used parallel to the shafting and are countersunk, as shown in Figure 13.40 Page 329.

The greatest hazard with exposed setscrew heads is that they will catch parts of loose clothing and then draw the worker into the machine.

The installation of u-type guards, wherever needed, is an objective that needs to be set by the safety and health manager. (Figure 15.40 on Page 330).

One approach to guarding large air compressors is to place them in a room by themselves.

Compressed air hoses with nozzles are often used to spray chips away from machine areas. Safety standards specify that the air pressure used for such purposes must not exceed 30 psi (Figure 15.41 on Page 330).

Excessive air pressure from these nozzles can make flying chips hazardous.

Compressed air can present hazards resulting in fatalities.
Chapter 16
Welding

Welding processes present some of the greatest hazards to both safety and health.

"welding," in a very broad sense includes: gas welding, electric-arc welding, resistance welding, and related processes such as soldering and brazing.

Process Terminology

Welding requires that material melt or fuse to form a rigid joint. Requiring temperatures above 800°F are needed.

Three basic categories of conventional welding are as follows:

• gas welding -is typified by the familiar oxyacetylene torch process, in which the very hot burning acetylene gas is made to burn even hotter by supplying pure oxygen to the flame.

• electric-arc welding -requires a small gap between two electrodes; one of which is usually the workpiece itself, and the other is a piece of welding rod (of a filler metal surrounded by a flux) which is held by a gripper and is consumed by the process. -(Figure 16.1)

• resistance welding -(Figure 16.4) is one of the least hazardous of welding processes and is widely used in mass-production manufacturing. The concept is to pass electrical current through the material to be welded, enabling the heat so generated to melt the material also physical pressure is applied at the point of the weld.

Gas Welding Hazards

Acetylene hazards
Gas welding cylinders usually contain a pressure greater than 2000 psi.

Acetylene cylinders should be kept valve end up both while in storage and while in use. It is common practice to use hand trucks to handle cylinders connected for use. However, do not tip the cylinders at an angle greater than 45° from vertical.

Acetylene cylinders have been known to leak around the valve stem, causing what welders call "stem fires."

Oxygen cylinders
Oxygen cylinders are more dangerous than acetylene cylinders. The reason for this danger is the extremely high pressure (2000 psi) contained by the oxygen cylinder. Figure 16.6 Page 376 notice the slots in the cap!!
When an oxygen cylinder is strapped to a wheeled cart or hand truck along with its companion acetylene cylinder and the regulator assembly is in place for welding, the cylinder is generally considered to be in operational status, not in storage. Therefore, industry practice says that the valve protection caps do not have to be in place in these situations.

A substance can suddenly become explosively combustible in the presence of pure oxygen under pressure. When oxygen and acetylene cylinders are stored together, the hazards are multiplied.

During storage a noncombustible barrier at least 5 feet high must separate oxygen and acetylene cylinders, or they must be moved apart at least 20 feet.

Torches and apparatus
Figure 16.7 Page 378 displays the assembly. The welder controls the proportion of volumes of the mix by adjusting the torch valves for oxygen and/or acetylene.

Arc Welding Hazards

The major hazards of arc welding are health hazards, fires and explosions, eye (radiation) hazards, and confined space hazards.

Equipment design
Welding requires large amounts of electrical power in the form of low-voltage, high-amperage circuits.

Grounding
The welder or other personnel can receive an electrical shock from contact with the machine if it is not properly grounded.

Resistance Welding Hazards

The cleanest, most healthful, and probably safest form of welding is resistance welding.

Shock hazards
Many resistance welding machines build up electrical energy in a bank of capacitors for sudden release when the weld is made. The voltage may reach hundreds or even thousands of volts at peak.

The capacitors that store this electrical energy should have interlocked doors and access panels. Not only must the interlock stop the power to the machine, it must also short-circuit all capacitors. Without it a lethal shock could occur.

Guarding
Spot and seam welding machines apply pressure to the materials when the weld is made. The operator can be injured from the mechanical hazards.

Fires and Explosions

Welding is one of the principal causes of industrial fires.

One of the most devastating and tragic industrial accidents in the nation's history occurred in Arkansas in the 1960s. A welder's spark started a fire in a missile silo, and 53 workers trapped inside the silo were killed.

When the job to be done in the confined space, both health and safety hazards are compounded.

Welding is not safe to watch directly because of the eye hazards.

Welding permits
The safety and health manager might do well to institute a procedure (a signed checklist) for mandatory permits to weld in general plant areas and in warehouses.

The safety and health manager's responsibility is to set up the permit system and ensure that it is executed properly by actually checking permits occasionally when welding.

Eye Protection

Eye protection for welding operations is important because welders need protection to prevent pain and discomfort from eye injury associated with eyeburn caused by intense radiation from arc welding.

Protective Clothing

Protective clothing should cover all skin areas that would otherwise be exposed to the arc rays. But ultraviolet burn is only one of several hazards against which protective clothing is intended. Hot, burning sparks or small pieces of molten metal can fall into openings around shoes or between pieces of clothing.

Leather is the traditional favorite material for welding gloves, aprons, and leggings because of its superior thermal protective qualities.

Hazards to the welder from falling sparks and weld metal are greatly increased when the welding must be done overhead.

Gases And Fumes

Contaminant categories
In Figure 16.9 Page 386 some welding dusts are more hazardous than others because they cause fibrosis, the building up of fibrous tissue in the lungs.

The most harmful dusts are those in which the microscopic particles have the shape of fibers instead of more rounded particles. Asbestos and silica are examples.

**Hazard potentials**
If the surface of the metal has a coating of material containing asbestos, this coating must be removed to prevent asbestos contamination of the air.

Galvanized is a term referring to a zinc coating on the metal to prevent rust. Welding on galvanized steel needs extra caution and good ventilation because the welding arc can produce a fume of zinc or of zinc oxide.

Plating metals are usually much more dangerous to weld than the iron or steel upon which the plating is used. Cadmium is a plating metal whose welding fumes are considered very dangerous.

Stainless steel is one of the most dangerous materials to weld because of its high chromium content.

**Chapter 17**
**Electrical Hazards**

The national center for health statistics reports approximately 500 to 1000 accidental electrocutions annually in the United States, with about 1 in 4 being industry and farm related.

**Electrocution Hazards**

Ordinary 110-volt circuits can easily kill,

Wet or damp locations are known to be hazardous, but even body perspiration and blood seeping from open wounds can provide the dampness which can make electrical contact fatal.

Point of contact is another important consideration because the current flows through the body, i.e. contact with hand results in the current traveling through the foot past the heart & lungs which can result in death.

Vital organs such as the heart and lung diaphragm can be affected, with possibly fatal results.

**Physiological effects**
An external electric shock can cramp or freeze muscles into a violent contraction—one that will not allow the victim to let go of the object contacted, or one that will stop breathing or stop the heart.

Common electric utility power supplies alternating current which cycles at a frequency of 60 Hertz. Which is one of the most dangerous frequencies to which the heart can be exposed. It can cause fibrillation.

Stopped breathing is due to cramped muscles, such as the diaphragm and those controlling rib cage expansion.

Figure 17-1 Page 394 summarizes the opinions of several experts.

Human skin, if dry, is a good insulator having a resistance or 100,000 ohms or more. If exposed to 110 volts the result is only about 0.0011 amperes (1 milliampere).

But add perspiration or other moisture to the skin, and the resistance drops sharply, to a level of about 500 ohms, resulting in 220 milliamperes exposure.

Case Study 17.1 Page 397 good stuff for future test questions.

Wiring
A typical 110-volt circuit has three wires: hot, neutral, and ground. Sometimes the neutral is called the "ground."

The purpose of the hot wire (usually a black insulated wire) is to provide contact between the power source and the device (load) that uses it. The neutral (usually a white insulated wire) completes the circuit by connecting the load with ground.

The third wire is the ground wire and is usually either green or is simply a bare wire. The purpose of the ground wire is safety.

GFCI protection is in addition to overcurrent protection such as circuit breakers or fuses.

Figure 17.5 explains how a GFCI works. Whenever the current flow in the neutral is less than the current flow in the hot wire, a ground fault is indicated, and the current flow is stopped by a switch that breaks the entire circuit.

Double insulation
Less than half of the electric hand tools in actual use are properly grounded. A common alteration is to cut off the third prong of the plug so that it can be plugged into an old two-wire receptacle.

The use of "double-insulated" (a nonconductive housing) tools is permitted in lieu of equipment grounding.
Fire Hazards

Fuses or circuit breakers, protect against both fire and electrocution, but their primary function is fire prevention.

Wire fires
One of the most common causes of fires of electrical origin are wires that become overheated because they conduct too much current. Wire diameters (gauges) must be properly sized to handle the current load expected.

Hazardous locations
The national electrical code defines the various conditions to classify hazardous locations into six categories. Within these classifications are various groups that identify the substance group that is causing the hazard.

Since classification is so complex, industry often relies on examples common in similar industries to decide whether a location is Division 1 or 2 or not of sufficient hazard to classify at all. Examples of some common hazardous locations are listed in Table 17.1 Page 408. Table 17.2 Page 410 lists various groups and classes.

Test equipment
The safety and health manager should have access to the following tools for occasional in-house inspections.

1. Circuit tester
(Figure 17.14) simply has two wire leads connected by a small lamp bulb, usually neon. Whenever one of the leads touches a hot wire and the other lead touches a grounded conductor, completing the circuit, the bulb glows.

2. Receptacle wiring tester
(Figure 17.15 Page 411) the user simply plugs the device into any standard 110-volt outlet and interprets the arrangement of indicator lights to determine whether the receptacle is wired improperly.

3. Continuity tester
Is used to check a dead circuit to see if all the connections are complete or to see whether a break in a conductor has occurred. Figure 17.17 Page 412.

Frequent Violations

Usually violations of the national electrical code.

1. Grounding of portable tools and appliances
2. Exposed live parts
3. Improper use of flexible cords
4. Marking of disconnects
5. Connection of plugs to cords

Chapter 18
Construction

The construction industry has long been recognized as more hazardous than most other workplaces.

The nature of the work requires risks that are not necessary in general industry.

Thus a set of standards for construction (Part 29 CFR 1926) has been maintained separately from the general industry (Part 29 CFR 1910) standards.

If OSHA cannot find a construction standard that covers a given hazard the compliance officer is free to turn to the general industry standards to write a citation.

Occasional remodeling or expansion projects result in construction and employees can become exposed to hazards created. Such hazards can be both physical and legal.

General Facilities

Lighting
There are standards for adequate lighting on construction sites, that specify minimum illumination intensities for various areas of 5 foot-candles for general construction area 3 foot-candles for storage areas.

Materials handling and storage
The heaviest load a floor will probably ever support is during its own construction. Planning is needed to prevent overloading and possible collapse.

Personal Protective Equipment

Construction requirements for personal protective equipment are similar to those for general industry.
1. Hardhats
2. Hearing protection
3. Eye and face protection
4. Fall protection- safety belts and lanyards tied to lifelines are essential to the safety of construction workers. Fall protection is usually considered from the standpoint of height, but working over or near water presents a different hazard.

Fire Protection
Construction sites have somewhat more latitude in distributing fire extinguishers than do general industries. Even an ordinary garden hose may be used in place of fire extinguishers.

The biggest problem is the handling of flammable liquids. For ordinary flammable liquids such as

**Electrical**

A principal requirement on construction sites is that all 15- and 20-ampere outlets have either ground fault circuit interrupter (GFCI) protection or a program of equipment ground conductor assurance, including inspection, testing, and recordkeeping.

The GFCI closely monitors any difference in current flow between the ground and neutral conductors, as low as fractions of a milliampere.

Temporary lighting is an electrical problem, often seen are ordinary incandescent bulbs suspended from electrical cords (designed for this purpose).

**Ladders and Scaffolds**

**Job-made ladders**
Construction companies often make their own ladders, and such ladders are not illegal if made properly (Figure 18.5 and Figure 18.6 Page 427).

If the ladder is the only means of access or exit from a working area for 25 or more employees, the double-cleat ladder is mandatory, unless two ladders are provided.

**Scaffolds**
Design safety factor for scaffolds and their components is a factor of 4. This factor increases to a factor of 6 for the suspension ropes supporting the suspended type of scaffolding.

The most popular scaffolds are the following types:

- welded frame (or "bedstead" scaffolds)
- manually propelled mobile scaffolds (on casters)
- two-point suspension (or “swinging" scaffolds)
- tube and coupler scaffolds

Figure 18.7 Page 429 illustrates minimums and maximums for plank overhang. Figure 16.8 illustrates the minimum for overlap, unless planks are secured from movement.

**Floors and Stairways**

The standard for guarding of open-sided floors and platforms is one of the most frequently cited standards in construction.
The vertical fall distance for construction is 6 feet. Thus an open-sided floor or platform 6 feet or more above the adjacent floor level is required to be guarded by a standard railing.

Runways 4 feet high or more must be guarded.

Cranes and Hoists

Particularly hazardous is the rear of the cab, which on many models swings outside the crawler or other substructure when the cab and boom rotate, as shown in Figure 18.9 Page 430.

A common worker practice is "riding the headache ball." Figure 18.11 identifies the headache ball as the ball-shaped weight used to keep a necessary tension on the wire rope when the hook is not loaded, the recommended practice is to use a lift cage attached to the crane hook.

Material and personnel hoists
Temporary external elevators are often used on construction sites to move workers and materials and must be designed, maintained, and used properly to avoid a serious hazard.

Latched gates are needed to guard the full width of the landing entrance for both material and personnel hoists.

Personnel hoists must have an electrical interlock that must not allow movement of the hoist when the door or gate is open.

Heavy Vehicles and Equipment

ROPS
The acronym ROPS represents the term rollover protective structures.

The purpose of the ROPS, illustrated in Figure 18.13, is to protect the operator from serious injury or death in the event the vehicle rolls over.

The following kinds of construction equipment require ROPS:
  • rubber-tired, self-propelled scrapers
  • rubber-tired, front-end loaders
  • rubber-tired dozers
  • wheel-type agricultural and industrial tractors
  • crawler tractors
  • crawler-type loaders
  • motor graders

Runover protection
Fatalities occur with heavy construction equipment due to personnel being run over by the equipment. Confrontation of this major fatality category has two main thrusts: operator visibility and pedestrian awareness.

Operator visibility can be hindered by frost, dirty or cracked windshields, and dust.

Pedestrian awareness can be accomplished by the use of a horn used to warn personnel. I.e. "backup alarms."

**Trenching and Excavations**

A major cause of construction fatalities is the sudden collapse of the wall of a trench or excavation.

Trenches are narrow, deep excavations; the depth is greater than the width, but the width is no greater than 15 feet, according to the standard definition.

A trench is more confined and generally more dangerous than other excavations, especially because both walls can collapse, trapping the worker.

The angle of repose is defined as the greatest angle above the horizontal plane at which a material will lie without sliding. The angle naturally varies with the material, and approximate angles are shown in Figure 18.14 Page 437.

Adding to the uncertainty of the cave-in hazard are certain hazard-increasing factors, such as:

- rainstorms, which soften the earth and promote slides
- vibrations from heavy equipment or street traffic nearby
- previous disturbances of the soil, as from previous construction or other excavations
- alternate freezing and thawing of the soil
- large static loads, as from nearby building foundations or stacked material

Table 18.2 on Page 438 gives the reader an idea of the types of materials used for shoring of trenches.

**Steel Erection**

Perhaps this work will always be dangerous, but the hazard has been mollified somewhat by requiring safety nets to be installed whenever the fall distance exceeds two stories or 25 feet. An alternative is to use scaffolds or temporary floors.

Review Case Study 18.1 on page 441.