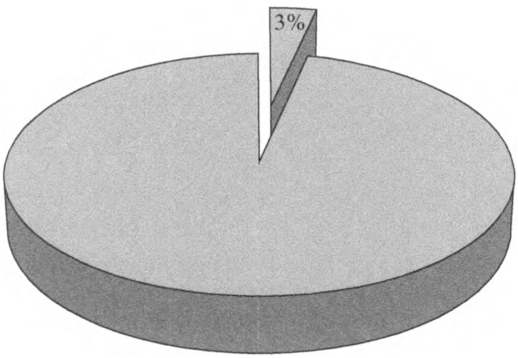
C H A P T E R 1 3

Fire Protection



Percentage of OSHA General Industry citations addressing this subject

This chapter deals with perhaps the oldest topic in occupational safety and health. Fire protection history dates back to the burning of Rome in 64 A.D. after which Emperor Nero specified fire-resistant materials for use in exterior walls in rebuilding the city. The original motivation for the creation of Underwriters' Laboratories in the United States was to satisfy insurance companies' concerns about the risk of fire (Cote, 2008). Despite the ancient history of fire protection, modern developments in the field place it in a very dynamic phase. More so than for other categories of safety and health, fire safety presents the safety and health manager with a wide variety of alternatives for dealing with hazards.

Industrial fire protection standards, when dealing with OSHA, formerly consisted of little more than dealing with fire extinguishers, their selection, placement, marking, inspection, and maintenance. True, there were a few obscure standards about such topics as "standpipe and hose systems," but almost all of the activity centered around fire extinguishers. Today, the field of industrial fire protection is much more sophisticated, recognizing such alternatives as emergency action plans, fire prevention, fire brigades, fire alarm signaling systems, fixed extinguishing systems, and automatic sprinkler systems. Rather than blindly following old specific standards for fire extinguishers, safety and health managers now have the opportunity to explore alternative strategies or combinations of strategies to accomplish the most cost-effective method of fire protection for their own circumstances. Even the federal standards have been changed to delegate such decision-making authority to industrial managers.

It is easy to oversimplify fire protection as meaning only fire extinguishment, but it really encompasses three fields: fire prevention, fire suppression, and personal protection (escape). Much of the criticism of old fire safety standards has been that they emphasized fire suppression and fire extinguishers, which may not be the safest alternative in some fire situations. Some firms wanted no extinguishers at all and desired to instruct employees to escape without attempting to extinguish fires. Their argument was that fire extinguishers are mainly for property protection, and, in an emergency, workers may be rather inept in using them. In such situations, the safest course of action for workers is to escape the danger without attempting to suppress the fire. The current standards recognize this rationale together with several shades of combination strategies. Before discussing these strategies in detail, some facts about fires should put the fire protection problem in perspective.

MECHANICS OF FIRE

Just as fire protection has three ingredients—prevention, suppression, and escape—fire itself has three ingredients: oxygen, heat, and fuel, as shown in the familiar fire triangle in Figure 13.1. By keeping in mind, these three essential physical ingredients of fire, strategies for prevention and suppression can be developed for various industrial circumstances. The third ingredient for fire protection, escape, stands alone as a different strategy, not dependent on the ingredients of fire.

INDUSTRIAL FIRES

Industry, more than most other elements of our society, has done a great deal to control fire hazards. Considering the incredible exposure to flammable liquids in refineries and chemical plants and the billions of labor hours spent in industrial plants every year, it is amazing that the number of fire deaths in all industrial plants is no more than the number who die in fires in taverns and prisons. In fact, more people died in a single fire in a supper club in Kentucky in 1977[1] than in all the

FIGURE 13.1
Fire triangle.

[1]Beverly Hills Supper Club fire, Southgate, Kentucky; 165 lives lost.

multiple-death industrial fires in the nation in that year and the two succeeding years combined. U.S. occupational fire fatality records were shattered by the fires generated by the terrorist attacks on September 11, 2001, in New York and Washington, D.C., but these fires were not accidental; they were more properly classified as acts of war.

The most dangerous industries from a fire hazard standpoint are mines, grain elevators (and mills), refineries, and chemical plants. The fire fatalities from these four industries dwarf the total for all remaining industries combined. For general manufacturing industries, the number of fire fatalities is extremely low. A major tragedy occurred in 1991 in Hamlet, North Carolina, where 25 people lost their lives in 35 minutes when a fire swept through the Imperial Foods poultry processing plant. An even worse tragedy occurred in New York in 1912, in the Triangle Shirtwaist Company fire, which claimed 145 lives. The Triangle Shirtwaist fire received so much publicity that it had a profound impact on regulations to control industrial fires in the United States, with the result that an excellent fire record was achieved in the decades following this terrible tragedy. The Imperial Foods tragedy has again reminded the public of the consequences of locked exits and complacency about fire hazards.

FIRE PREVENTION

The best way to deal with fires is to prevent their occurrence, just as engineering controls were found in Chapter 12 to be preferable to personal protective equipment. Effective fire prevention requires anticipation of fire sources. Each facility is different and requires an individual analysis of potential fire sources. Once the hazards are identified, decisions must be made as to who has responsibility for controlling the hazards. These decisions should be documented in a fire prevention plan.

A principal cause of industrial fires is overheated bearings or hot machinery and processes. Another cause is clogged or dirty ventilation filters or ducts, especially when the clogging material is a flammable or combustible air contaminant. Some of these causes can be averted by adopting an effective preventive maintenance program. Such a program, while decreasing the likelihood of fire, may also extend the life of equipment. The safety and health manager may see an opportunity in this strategy to save production costs while furthering the cause of fire safety.

Another component in a fire prevention plan is a strategy for housekeeping. Accumulation of combustible dusts in grain elevators and paint residues in spray painting operations are good examples of how poor housekeeping can contribute to fire hazards. Even ordinary combustible paper and material waste can be a fire hazard.

DUST EXPLOSIONS

This text has made several references to the hazards of dust and dust explosions. In Chapter 7, the housekeeping function of keeping floors and aisles clean from the accumulation of combustible dusts was emphasized by illustrating with an example of a large OSHA fine in a grain elevator. Grain elevators are not the only workplaces that are subject to the hazards of dust explosions, as Case Study 13.1 will emphatically show.

CASE STUDY 13.1

IMPERIAL SUGAR REFINERY DUST EXPLOSION AND FIRE

In the evening shift on February 7, 2008, a tremendous explosion ripped through the Imperial Sugar Refinery in Port Wentworth, Georgia, a suburb of Savannah. The explosion and fire, which continued for several days, killed 13 workers, a significant percentage of the total number of workers on duty at the refinery (around 100 at the time of the explosion). Nearly half of the workers in the plant were taken to the hospital. OSHA investigation revealed that the cause was sugar dust, an explosively combustible material when it is airborne. The sugar dust cloud was ignited when a large metal bucket in a storage silo sparked against metal siding. Besides the loss of life, an immense OSHA fine was levied on Imperial Sugar, $8,777,500 in proposed penalties, the third largest in the history of OSHA. The accusations were aggravated by OSHA allegations that after the explosion the company failed to take adequate corrective action at Gramercy, Louisiana, the location of another Imperial Sugar refinery. The explosion actually prompted an imminent danger inspection of the Gramercy site, where multiple willful violations were found also.

Several lessons can be learned from Case Study 13.1:

1. Dust explosions are a serious hazard.
2. Housekeeping to minimize airborne combustible dusts should be a priority.
3. Corrective actions after a major accident has occurred are essential.
4. Prevention is an important ingredient in an overall fire protection program.

The hazards of dust explosions will be addressed again in Chapter 17, Electrical Hazards, because electrical arcing is such a difficult source of ignition to control in the presence of combustible dusts.

EMERGENCY EVACUATION

Using the *escape strategy* for dealing with fires or other emergencies, the employer must prepare a written *emergency action plan*. The emergency action plan concept has been around for many years for hospitals, schools, and institutions, and more recently, has been extended to industries in general.

Alarm Systems

Crucial to an emergency action plan is an employee alarm system. However, alarm systems are not as simple as they may seem. There are searching questions that must be asked: Will persons recognize the signal as a fire alarm? What about deaf or blind employees? Audible, visual, and tactile systems must be considered, or perhaps combinations of these systems. In small workplaces, even direct voice communication may be the best fire alarm medium. Public address systems may be used in larger facilities, but the system should provide that emergency messages take priority.

System reliability is important to fire alarms because a failure within the system may not be immediately obvious. Think about it for a moment. If an alarm system would quietly develop a malfunction, when would it be noticed? Too often, it is during an actual emergency that the malfunction is discovered—too late to do any good. Case Study 13.2 illustrates this unfortunate circumstance. Some sophisticated systems have built-in monitor circuits to supervise reliability. Such systems do not need testing as often as do simple alarm systems, which have no such monitoring circuits. When repairs are being made, some type of backup system is needed to provide continuous protection. The backup system might even employ "runners" or telephones or other informal systems, but the safety and health manager should document what backup system is in place. The importance of both alarm system testing and a backup system when the primary system malfunctions is further illustrated in Case Study 13.2.

Fire Detection Systems

Smoke alarms and other detection devices may be used to trigger the alarm system. However, it should be noted that automatic smoke alarms are not mandatory in American industries in general. Even manual or visual systems can be considered alarm systems.

If automatic detection systems are employed, care must be taken to maintain and protect the equipment. Most detection systems are delicate instruments and will not withstand the rigors of the industrial environment. Conditions to be considered are dust, corrosive atmospheres, weather exposure, heat from processes, and mechanical damage.

CASE STUDY 13.2

HIGH-RISE OFFICE FIRE EVACUATION

A 10-story office building was equipped with a cafeteria in which a fire started in an exhaust flue over the cooking surface. The cafeteria worker who discovered the fire properly actuated the fire alarm switch to signal evacuation of the building, but the alarm system failed to operate. A disaster was averted by telephoning each of the 10 floors, and a successful evacuation of the building was effected. In the aftermath of the emergency, a new system was installed consisting of both audible and visual alarms, and, in addition, an emergency telephone was installed on each floor.

People are sometimes reluctant to sound fire alarms, with tragic consequences. Hotel managers are particularly unwilling to alarm occupants. The typical response from a hotel front desk when an occupant calls in a fire alarm is to send a bellman to investigate. It is rational to consider the hazards of panic when a fire alarm is sounded. However, this rationale is sometimes permitted to be an excuse for failing to take action.

FIRE BRIGADES

Some firms may adopt a strategy in which employees are organized into 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.

Employee Fitness

Volunteering to join the fire brigade is not sufficient to qualify the worker to fight fires. Conditions that may be hazardous include heart disease, epilepsy, or emphysema. Other conditions, such as ruptured eardrums or the wearing of a beard, may make the use of respiratory equipment ill advised. The safety and health manager should be sure that the fire brigade volunteers are screened, and a physician's certificate may be necessary for questionable cases. Volunteers unfit for interior structural firefighting may be used in other tasks.

Firefighter Training

Many states have fire training academies, and safety and health managers should find out what schools and academies are available for their fire brigade members. Interior structural firefighting is more demanding, and fire brigade members assigned to such tasks should be trained at least quarterly. Other fire brigade members should be trained at least annually. In addition, firefighting equipment to be used by the fire brigade should be inspected annually, and fire extinguishers should be inspected monthly.

Protective Clothing and Apparatus

If the firm elects to have fire brigade members fight interior structural fires, protective clothing and respirators must be provided. This includes protective boots or shoes, fire-resistant coats, gloves, and head, eye, and face protection.

One concept stressed for self-contained breathing apparatus units is the mode for airflow into the mask. At this point, the reader may want to review the three modes of respirator air-flow discussed in Chapter 12. The preferred mode for firefighting is one of the positive-pressure types: pressure demand or continuous flow. The only valid argument for using simple demand flow is that this mode permits exposures of longer duration for a given charge. If the employer believes that the demand-flow mode is essential, quantitative fit testing is necessary for each firefighter.

FIRE EXTINGUISHERS

Fire extinguishers are still the most effective method of immediately controlling a very local fire before disastrous consequences ensue. The safety and health manager needs to understand the various fire classes and the type of extinguishers appropriate for each class.

Fire Classes

The fire protection field classifies fires into four categories. Application of the wrong extinguishment medium to a fire can do more harm than good.

Table 13.1 describes the four classes of fires, sample appropriate extinguisher media, and the maximum travel distance specified for extinguishers for each type of fire. Liquefied petroleum gas (LPG) fires, although technically Class B, are really not adequately addressed by any of the four classifications. Such fires are extremely dangerous, and fire extinguishers are not appropriate for their control. LPG fires should be extinguished by professional firefighters using powerful water-spray systems.

The key to determining whether an extinguisher is appropriate for a given class of fire hazard is to check the approval marking on the extinguisher itself. Some types of extinguishers have been found to be hazardous and are forbidden regardless of prior approval markings. These types are listed in Table 13.2. Some extinguishers may be approved for more than one classification of fire. These multipurpose fire extinguishers typically employ a dry chemical medium. Although dry chemical extinguishers are growing in popularity, they are not a panacea. Expensive equipment such as computers can be fouled or even ruined by the application of a dry chemical extinguisher when a CO_2 extinguisher would have been satisfactory. Another problem is caking of the powdered, dry chemical medium, causing it to fail to deploy. Foam or water extinguishers may also be cheaper for the more ubiquitous Class A fires. Another category of fire extinguisher is Class K for use in fires involving cooking fluids such as oils and fats. While this special circumstance has a dedicated fire extinguisher class, there is not a class K fire.

TABLE 13.1 Four Classes of Fires and Appropriate Extinguishing Media

Fire class	Description	Example extinguishing media	Maximum OSHA-authorized travel distance to nearest extinguisher
A	Paper, wood, cloth, and some rubber and plastic materials	Foam, loaded stream, dry chemical, water	75 feet
B	Flammable or combustible liquids, flammable gases, greases, and similar materials, and some rubber and plastic materials	Bromotrifluoromethane, carbon dioxide, dry chemical, foam, loaded stream	50 feet
C	Energized electrical equipment	Bromotrifluoromethane, carbon dioxide, dry chemical	Nonspecific maximum distribute "on the basis of the appropriate pattern for existing Class A or B hazards"
D	Combustible metals such as magnesium, titanium, zirconium, sodium, lithium, and potassium	Special powders, sand	75 feet

TABLE 13.2 Forbidden Fire Extinguishers

1. Carbon tetrachloride
2. Chlorobromomethane
3. Soldered or riveted shell self-generating soda acid or self-generating foam or gas cartridge water-type portable fire extinguishers that are operated by inverting the extinguisher to rupture the cartridge or to initiate an uncontrollable pressure-generating chemical reaction to expel the agent

Source: Code of Federal Regulations, 29 CFR 1910.157.

Inspection, Testing, and Mounting

OSHA has abandoned the rule requiring fire extinguisher tags indicating their inspection status, but still requires the employer to maintain records of annual maintenance for each fire extinguisher for up to 1 year after the last entry or the life of the shell, whichever occurs earlier. In addition, a visual inspection is required monthly. Many employers have found it expedient to retain the tag system even though it is no longer required. Thus, when anyone requests to see the inspection record for a given fire extinguisher, it is immediately available on the tag attached to the extinguisher.

In addition to the monthly and annual inspections, fire extinguishers must receive a hydrostatic test according to a prescribed test schedule. Fire extinguisher shells deteriorate from mechanical damage or corrosion and may be unsafe for containing pressures inside. The hydrostatic test places the extinguisher under a test pressure to determine whether it can safely contain the pressures to which it will be subjected in use. The test has technical specifications and must be done by a trained person using suitable equipment and facilities. The safety and health manager invariably leaves the hydrostatic tests for the professional fire extinguisher service to perform.

Another big OSHA enforcement issue used to be the mounting height and identification of mounting of fire extinguishers. OSHA citations for mounting, identification, and inspection tagging of fire extinguishers once amounted to more than half of all OSHA violations named in fire protection citations. These requirements have all been eliminated or drastically changed by rewording them in performance language. The current standard permits the employer the latitude of mounting extinguishers high on the wall, out of the way of forklift truck traffic, accessing them by rope and pulley. The employer may select any convenient mounting scheme provided that the extinguishers are readily accessible without subjecting employees to possible injury.

Training and Education

A facility looks well equipped and protected when fire extinguishers are placed about the workplace, readily accessible for use in an emergency. However, the appalling reality is that few employees know how to use a fire extinguisher effectively, and some would even be afraid to use the extinguishers if they knew how. This is especially true of fire extinguishers or hose systems located behind glass doors. For most people, there is a great reluctance to break glass even in an emergency. A study of the nursing staff conducted in an Ohio hospital revealed that most knew nothing about, and were afraid to use, fire extinguishers. Accordingly, the safety manager in charge set out to train the nurses to use fire extinguishers in an emergency. A hospital bed was taken outdoors and set afire to provide a simulated fire emergency for the nurses to practice on. The field of industrial safety has now recognized the need for fire extinguisher training, and such training has been accepted as standard for general industry. Training is required on initial employment and at least annually thereafter.

STANDPIPE AND HOSE SYSTEMS

Some employers choose to install standpipe and hose systems for firefighting, and these systems can be employed in lieu of general distribution of fire extinguishers in most cases. Standpipe and hose systems come in various ratings or classes. Large-diameter ($2\frac{1}{2}$-inch) hose is difficult or even dangerous to handle and is intended for professional firefighters. Large-diameter hose is designated as Class I and is exempted from coverage by the OSHA General Industry standard for standpipe and hose systems. Smaller diameter standpipe and hose systems are for employee use, and federal enforcement authorities take an interest in the adequacy of the equipment and in its maintenance and use.

Equipment

Some standpipe and hose systems can be quite ancient. These old systems can usually be retained as long as they are serviceable and meet annual test requirements. However, when replacements are made, new equipment should conform to all current standards. Examples of modern system changes are as follows:

1. *Shutoff*-type nozzles
2. *Lining* for hose
3. Dynamic pressure minimums at the nozzle
4. Hydrostatic *testing* upon installation

The water supply for standpipe and hose systems can be provided by either elevated water-supply tanks or pressure tanks. The supply must be sufficient to provide 100 gallons per minute flow for at least 30 minutes. This calculates to 3000 gallons per use period, but remember that it takes considerably more than 3000 gallons to provide the head pressure to maintain the 100-gallon-per-minute flow throughout the 30-minute period. One seemingly clever idea is to forget about standpipes or pressure tanks and connect hose systems to city water supplies. However, the flaw in that theory is the adequacy (pressure and flow) of the supply, which usually cannot meet the 100-gallon-per-minute flow requirement.

Maintenance

The ancient systems described earlier can create some unpleasant surprises when the hose is deployed for use. Hemp and linen systems are especially subject to deterioration. After hanging on the rack for many years without use, the hose may break apart or disintegrate when taken off the rack for use in an emergency. Hose systems should be checked annually and after each use. In the case of hemp or linen hose systems, the hose must be reracked using a different fold pattern.

AUTOMATIC SPRINKLER SYSTEMS

Automatic sprinkler systems present a paradox because they affect employee safety, but are usually installed principally to protect property and to lower insurance rates. If such a system is *voluntarily* installed by the employer to protect property, should it be required to meet personal safety standards? And if an existing system does not meet the latest revisions to standards, should it be dismantled and withdrawn from use? This would hardly be in the interest of safety.

Sometimes a good sprinkler system is installed only to be made ineffective by incorrect usage of the space protected. One error is to allow the sprinkler heads to become fouled by materials such as paint spray residues. 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 a fire does occur, the paper bags will either burn away or be washed away by the water spray so that they do not interfere with the fire suppression action of the sprinklers.

Another error with automatic sprinklers is to stack material too close to the ceiling. This interferes with the distribution of spray from the sprinkler head. At least an 18-inch clearance must be used, as shown in Figure 13.2, to permit the sprinkler spray to be well distributed.

FIXED EXTINGUISHING SYSTEMS

Technically speaking, automatic sprinkler systems are fixed extinguishing systems, but what is usually meant by a fixed extinguishing system is a more local system for controlling special fire hazards such as kitchen grills or tempering tanks. Again, the principal objective may be property protection and insurance-rate reduction, but steps must be taken to prevent the system, which may discharge dangerous gases or other agents, from becoming a hazard to employees. Thus, if the discharge of the system is not obvious, it is necessary to warn employees, perhaps with a discharge alarm, that dangerous agents are being expelled into the atmosphere. 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.

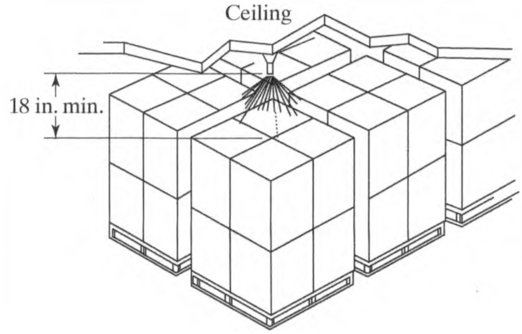


FIGURE 13.2

Minimum vertical clearance between stacked material and sprinkler head is 18 inches to permit distribution of spray.

Fixed extinguishing systems are somewhat like giant, fixed, automatic fire extinguishers. Many of the maintenance procedures appropriate for portable fire extinguishers are also appropriate for fixed extinguishing systems. Like portable extinguishers, fixed systems are required to be inspected annually. Corresponding to the monthly visual inspections of portable extinguishers is a somewhat more comprehensive semiannual inspection for fixed systems to determine whether containers are charged and ready for operation. If the containers are factory charged and have no gauges or indicators, they must be weighed to determine charge. A weight decrease of 5% or a pressure decrease of 10% is considered within tolerance. Discussion of specific systems follows with requirements for each.

Dry Chemical Systems

The word *chemical* in dry chemical systems should be remembered, and the question to be asked is whether the extinguishing chemical will produce any undesirable reaction with process reagents or perhaps foams and wetting agents also employed. There is more than one type of dry chemical available, and generally these chemicals are not to be mixed when filling the cylinders or containers. Mixing is permitted if the chemical to be added is "compatible" with the chemical stated on the approval nameplate of the system.

Dry chemicals used for extinguishing agents are usually not dangerous to the health or safety of personnel. However, the actual distribution of the chemical powder during an emergency may obscure vision, preventing escape. A possibility such as this calls for a predischarge employee alarm system as described earlier.

The biggest problem with dry chemical systems is the caking or lumping of the agent. Humid climates or moisture-producing processes subject the system to a greater risk of caking. Caking can render a dry chemical useless, so the chemical should be sampled annually to be certain that moisture is not causing caking.

Other Fixed Systems Agents

Many fixed extinguishing systems employ carbon dioxide, Halon 1211, or Halon 1301 gases. These systems have the advantage of not requiring as much cleanup after the emergency as other systems, but all three of 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.

Water spray and foam agents are less dangerous to employees, but necessary volumes required to be effective may introduce egress hazards. Drainage must be directed away from work areas and must not obstruct egress paths.

SUMMARY

The many strategies for dealing with industrial fire hazards can be grouped under the general categories of prevention, suppression, and escape, or combinations of these categories. Current applicable industrial standards encompass all of these strategies.

It is necessary to keep the hazards of industrial fires in perspective. Industrial fires cause very little loss of life and injury now, compared with fire deaths elsewhere and occupational fatalities and injuries from other causes. In light of this perspective, it may seem that emphasis on equipment specifications, regular inspection of extinguishers, personnel training, and written plans is somewhat misplaced. However, the excellent record of industry in controlling fire hazards on the job should not be allowed to induce complacency now that success has been achieved. There is no doubt that the adherence to strict fire codes is what has helped industry achieve such a superior control of fire hazards compared to residential and other fire exposures. An example of the tragic consequences of not adhering to fire codes and life safety codes was the fire at the Imperial Foods poultry processing plant in 1991.

The beginning of this chapter identified fire protection as the oldest of topics in occupational safety and health. There is perhaps a correlation between the facts that industrial fire protection is an old endeavor and that it is also a very successful endeavor. Perhaps with time, even the newer fields of occupational safety and health covered in other chapters of this book will achieve the same high degree of safety and health as has already been achieved for fire protection.

EXERCISES AND STUDY QUESTIONS

13.1 Should fire extinguishers be required in all industrial plants? Why or why not?
13.2 What are the three major fields of fire safety?
13.3 What argument does industry offer against providing fire extinguishers?
13.4 Which accounts for more workplace fatalities, fire or workplace violence?
13.5 How does industry compare to other elements of society in the control of fire hazards?
13.6 Which industrial fire claimed more lives, Triangle Shirtwaist or Imperial Foods?
13.7 How many lives were lost in the Beverly Hills Supper Club Fire in Kentucky in 1977? How did this number compare with industrial fires in the nation that year?
13.8 Name some items to be included in fire prevention plans.
13.9 How is preventive maintenance related to fire hazards?
13.10 How can automatic audible alarm systems fail to warn employees of a fire emergency?
13.11 Are automatic smoke alarms required in industrial plants?
13.12 Why does an employee sometimes notice a fire in the plant, but fail to sound the alarm?
13.13 Are industrial plants required to have fire brigades?
13.14 How often must fire brigade members be trained?
13.15 Name some conditions that would make an employee unfit to serve in a fire brigade.
13.16 Identify the four classes of fires. Give example extinguishing media for each.
13.17 What extinguishment medium is used for LPG fires?
13.18 Identify the typical fire extinguisher medium (fill substance) for multipurpose use (e.g., for use in a Class A, B, or C fire).
13.19 What are the advantages and disadvantages of dry chemical as a fire extinguishment medium?
13.20 How often must fire extinguishers be inspected?
13.21 Are fire extinguishers required to be mounted at a certain distance from the floor?
13.22 How often are employees required to be trained to operate fire extinguishers?
13.23 Name some modern requirements for standpipe and hose systems.

13.24 Why are city water supplies usually unacceptable for directly supplying hose systems for fire protection?
13.25 Are industries required to have automatic sprinkler systems? Explain.
13.26 Why are paper bags placed over sprinkler spray heads?
13.27 How close to the automatic sprinkler head in a warehouse is it permissible to stack material?
13.28 If a fixed extinguishing system has no gauges or indicators, how can its charge condition be determined?
13.29 Name some gases employed in fixed extinguishing systems.
13.30 Explain why ruptured eardrums would represent a hazard to firefighters.
13.31 Name three acceptable media for use in fire alarm systems.
13.32 What are the two principal ingredients of a fire prevention plan?
13.33 Describe the 1991 industrial fire tragedy that resulted from failure to follow fire and life safety codes.
13.34 In terms of lives lost, what was the worst fire of the twentieth century in a U.S. manufacturing plant? What was the silver lining to this terrible tragedy?
13.35 A company has a standpipe system that has a capacity of 3000 gallons of water. Pressure is maintained by gravity head. Is this system sufficient to meet standards for standpipe systems? Why or why not?
13.36 Explain the difference between dynamic pressure and static pressure.
13.37 Are fire extinguishers required to have attached tags that document their inspection status? Explain.
13.38 How long are fire extinguisher inspection records required to be maintained?
13.39 What is the specific purpose of hydrostatic tests for fire extinguishers (i.e., what specific hazards are the tests intended to guard against)?
13.40 Why does the safety and health manager usually choose not to have hydrostatic tests for fire extinguishers performed in-house?
13.41 Name two reasons why a fire extinguisher might fail a hydrostatic test.
13.42 Of the three modes of respirator flow, which two are preferred for firefighters? What is required if the third mode is used?
13.43 What is the worst day in the history of occupational fire deaths in the United States? Would you classify these deaths as accidental?
13.44 A principal component of an emergency evacuation system is an employee alarm system. What design questions must be considered in developing an effective employee alarm system?
13.45 What are some of the concerns when deciding to employ automatic fire detection systems?
13.46 How has the concept of performance standards dramatically changed OSHA's approach to citation of fire extinguisher standards?
13.47 The maximum allowable distance to the nearest fire extinguisher is usually 75 feet. For some types of fire, the maximum allowable distance is only 50 feet. Explain this difference.
13.48 What size hose is intended only for professional firefighter use?
13.49 What type of firehose system is exempt from OSHA General Industry standards for standpipe and hose systems?
13.50 What fire hazard might be introduced when material is stacked too high in a storage room?
13.51 What can be done to prevent fouling of automatic sprinkler system nozzles by paint spray residues?
13.52 Why is simply providing a sufficient number of fire extinguishers not an adequate measure of protection.
13.53 How can dry chemical fire extinguishers present another hazard when they are deployed?

13.54 **Design Case Study.** You are called on as a consultant to specify the type of fire extinguisher to be used for extinguishing LPG fires. What is LPG and to what fire class does it technically belong? What type of fire extinguisher, if any, would you specify for LPG? What other recommendations might be appropriate?

RESEARCH EXERCISES

13.55 Use the Internet to find sources of fire safety checklists.

13.56 Do research to find fire suppression systems that do not require human intervention.

13.57 Research the waterless fire suppression system FM200.

13.58 Use the Internet to price currently available portable, handheld fire extinguishers and where they may be purchased.

13.59 Examine current fatality statistics to determine how each of the following causes of death rank among workplace fatalities:

- **(a)** Falls
- **(b)** Electrocutions
- **(c)** Oxygen deficiency
- **(d)** Exposure to caustic, noxious, or allergenic substances
- **(e)** Motor vehicle accidents
- **(f)** Homicide or other workplace violence
- **(g)** Fire

What percentage of the total is attributed to each?

STANDARDS RESEARCH QUESTIONS

13.60 Search the OSHA General Industry standard for OSHA's current strategy for dealing with fire extinguishers. Explain OSHA's general position regarding fire extinguishers.

13.61 What are OSHA's general concerns about fire brigades? Justify your answer with reference to OSHA fire protection standards. Include a discussion of OSHA's enforcement activity pertaining to fire brigades. Cite inspection statistics.

13.62 Study OSHA General Industry standards for fire alarm systems. Examine enforcement activity for such systems using the database on the Companion Website.