

850

NFPA 850  
Fire Protection  
for Electric  
Generating  
Plants  
1992 Edition



National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101  
An International Standards-Making Organization

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The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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**NFPA 850**  
**Recommended Practice for**  
**Fire Protection for Electric Generating Plants**  
**1992 Edition**

This edition of NFPA 850, *Recommended Practice for Fire Protection for Electric Generating Plants*, was prepared by the Technical Committee on Electric Generating Plants and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 18-21, 1992 in New Orleans, LA. It was issued by the Standards Council on July 17, 1992, with an effective date of August 14, 1992, and supersedes all previous editions.

The 1992 edition of this document has been approved by the American National Standards Institute.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

**Origin and Development of NFPA 850**

The Committee on Non-Nuclear Power Generating Plants was organized in 1979 to have primary responsibility for documents on fire protection for non-nuclear electric generating plants. Begun early in 1980, the first edition of NFPA 850 was officially released in 1986 as the *Recommended Practice for Fire Protection for Fossil Fueled Steam Electric Generating Plants*.

The second edition of NFPA 850 was issued in 1990 under the revised title of *Recommended Practice for Fire Protection for Fossil Fueled Steam and Combustion Turbine Electric Generating Plants*. This second edition incorporated a new Chapter 6 on the identification and protection of hazards for combustion turbines.

In 1991 the Committee changed its name to the Technical Committee on Electric Generating Plants. This simplified name was made to reflect the Committee's scope to cover all types of electric generating plants except nuclear.

This latest edition of NFPA 850 incorporates a new Chapter 7 on alternative fuel electric generating plants. As part of these changes, the document title was revised to the *Recommended Practice for Fire Protection for Electric Generating Plants*. Various other technical and editorial changes were also made.

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**NFPA 850****Recommended Practice for****Fire Protection for Electric Generating  
Plants****1992 Edition**

NOTICE: Information on referenced publications can be found in Chapter 9.

**Chapter 1 Introduction**

**1-1 Scope.** This document provides recommendations (not requirements) for fire prevention and fire protection for electric generating plants, except as follows: nuclear power plants are addressed in NFPA 803, hydroelectric plants are addressed in NFPA 851, and combustion turbine units of 7500 hp or less are addressed in NFPA 37.

**1-2 Purpose.** This document is prepared for the guidance of those charged with the design, construction, operation, and protection of gas, oil, alternative fuels (i.e., municipal solid waste, refuse derived fuel, biomass, rubber tires, and other combustibles) or coal-fired steam and combustion turbine electric generating plants. This document provides fire prevention and fire protection recommendations for the safety of construction and operating personnel, the physical integrity of plant components, and the continuity of plant operations. Nothing in this document is intended to restrict new technologies or alternative arrangements.

**1-3 Application.**

**1-3.1** This document is intended for use by persons knowledgeable in the application of fire protection to electric generating plants.

**1-3.2** The recommendations contained in this document are intended for new installations only, as the application to existing installations may not be practicable.

**1-3.3** It must be recognized that rigid uniformity of generating station design and operating procedures does not exist and that each facility will have its own special conditions that impact on the nature of the installation. Many of the specific recommendations herein may require modification after due consideration of all local factors involved.

**1-4 Definitions.**

**Alternative Fuels.** Solid fuels such as municipal solid waste (MSW), refuse derived fuel (RDF), biomass, rubber tires, and other combustibles that are used instead of gas, oil, or coal in a boiler to produce steam for the generation of electrical energy.

**Approved.** Acceptable to the "authority having jurisdiction."

**NOTE:** The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

**Authority Having Jurisdiction.** The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

**NOTE:** The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction." In many circumstances the property owner or his designated agent assumes the role of the "authority having jurisdiction", at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

**Biomass.** A boiler fuel manufactured by means of a process that includes storing, shredding, classifying, and conveying of forest and agricultural byproducts (e.g., woodchips, rice hulls, sugar cane, etc.).

**Combustible.** Any material that does not comply with the definition of either noncombustible or limited combustible.

**Combustible Liquid.** A liquid having a flash point at or above 100°F (37.8°C). (See NFPA 30, *Flammable and Combustible Liquids Code*.)

**Fire Barrier.** A fire barrier is a continuous membrane, either vertical or horizontal, such as a wall or floor assembly, that is designed and constructed with a specified fire resistance rating to limit the spread of fire and that will also restrict the movement of smoke. Such barriers may have protected openings.

**Fire Loading.** The amount of combustibles present in a given area, expressed in Btu per sq ft (kJ m<sup>2</sup>).

**Fire Point.** The lowest temperature at which a liquid in an open container will give off sufficient vapors to burn when once ignited. It generally is slightly above the flash point.

**Fire Prevention.** Measures directed toward avoiding the inception of fire.

**Fire Protection.** Methods of providing for fire control or fire extinguishment.

**Fire Protection Rating.** The time, in minutes or hours, that materials and assemblies used as opening protection have withstood a fire exposure as established in accordance with test procedures of NFPA 252, *Standard Methods of Fire Tests of Door Assemblies*, and NFPA 257, *Standard for Fire Tests of Window Assemblies*, as applicable.

**Fire Rated Penetration Seal.** An opening in a fire barrier for the passage of pipe, cable, duct, etc., that has been sealed so as to maintain a barrier rating.

**Fire Resistance Rating.** The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251, *Standard Methods of Fire Tests of Building Construction and Materials*.

**Flammable Liquid.** Any liquid having a flash point below 100°F (37.8°C) and having a vapor pressure not exceeding 40 psia (276 kPa) absolute pressure at 100°F (37.8°C). (See NFPA 30 *Flammable and Combustible Liquids Code*.)

**High Fire Point Liquid.** A combustible dielectric liquid listed as having a fire point of not less than 572°F (300°C).

**Interior Finish.** The exposed interior surfaces of buildings including, but not limited to, fixed or movable walls and partitions, columns, and ceilings. Interior finish materials are grouped in the following classes:

*Class A Interior Finish.* Materials having flame spread 0-25, smoke developed 0-450 when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*. Includes any material classified at 25 or less on the flame spread test scale and 450 or less on the smoke test scale where any element thereof when so tested does not continue to propagate fire.

*Class B Interior Finish.* Materials having flame spread 26-75, smoke developed 0-450 when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*. Includes any material classified at more than 25, but not more than 75, on the flame spread test scale and 450 or less on the smoke test scale.

**Labeled.** Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

**Less Flammable Liquid.** A combustible dielectric liquid listed as having a fire point of not less than 572°F (300°C).

**Limited Combustible.** As applied to a building construction material, a material, not complying with the definition of noncombustible material, that in the form in

which it is used has a potential heat value not exceeding 3500 Btu per lb ( $8.14 \times 10^6$  J/kg) (see NFPA 259, *Standard Test Method for Potential Heat of Building Materials*), and complies with one of the following paragraphs (a) or (b):

(a) Materials having a structural base of noncombustible material with a surfacing not exceeding a thickness of  $\frac{1}{8}$  in. (3.175 mm) that has a flame spread rating not greater than 50.

(b) Materials, in the form and thickness used, other than as described in (a), having neither a flame spread rating greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread rating greater than 25 nor evidence of continued progressive combustion as tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*.

Materials subject to increase in combustibility or flame spread rating beyond the limits herein established through the effects of age, moisture, or other atmospheric condition shall be considered combustible.

**Listed.** Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

**Mass Burn.** A process in which municipal solid waste is hauled directly to a tipping floor or storage pit and then is used as a boiler fuel without any special processing.

**Municipal Solid Waste (MSW).** Solid waste materials consisting of commonly occurring residential and light commercial waste.

**Noncombustible.** A material that in the form in which it is used and under the conditions anticipated will not aid combustion or add appreciable heat to an ambient fire. Materials when tested in accordance with ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, and conforming to the criteria contained in Section 7 of the referenced standard are considered as noncombustible.

**Nonflammable Fluid.** A nonflammable dielectric fluid that does not have a flash point and is not flammable in air.

**Refuse Derived Fuel (RDF).** A boiler fuel manufactured by means of a process that includes storing, shredding, classifying, and conveying of municipal solid waste.

**Should.** Indicates a recommendation or that which is advised but not required.

**1-5 Units.** Metric units in this document are in accordance with the International System of Units, which is officially abbreviated SI in all languages. For a full explanation see the ASTM E380 ANSI Z210.1, *Metric Practice Guide*.

## Chapter 2 Administrative Controls

### 2-1 General.

**2-1.1** This chapter provides recommended criteria for the development of administrative procedures and controls necessary for the execution of the fire prevention and fire protection activities and practices for electric generating plants.

**2-1.2** The administrative controls recommended in this chapter should be reviewed and updated periodically.

**2-1.3** The intent of this chapter can be met by incorporating the features of this chapter in the plant's operating procedures or otherwise as determined by plant management.

### 2-2 Management Policy and Direction.

**2-2.1** Corporate management should establish a policy and institute a program to promote the conservation of property and continuity of operations as well as protection of safety to life by adequate fire prevention and fire protection measures at each facility.

**2-2.2** Proper preventative maintenance of operating equipment as well as adequate operator training are important aspects of a viable fire prevention program.

**2-3 Fire Risk Evaluation.** A fire risk evaluation should be initiated as early in the design process as practical to assure that the fire prevention and fire protection recommendations as described in this document have been evaluated in view of the plant-specific considerations regarding design, layout, and anticipated operating requirements. The evaluation should result in a list of recommended fire prevention features to be provided based on acceptable means for separation or control of common and special hazards, the control or elimination of ignition sources, and the suppression of fires.

**2-4 Fire Prevention Program.** A written plant fire prevention program should be established and as a minimum should include the following:

(a) Firesafety information for all employees and contractors. This information should include, as a minimum, familiarization with fire prevention procedures, plant emergency alarms and procedures, and how to report a fire.

(b) Documented plant inspections including provisions for handling of remedial actions to correct conditions that increase fire hazards.

(c) A description of the general housekeeping practices and the control of transient combustibles.

(d) Control of flammable and combustible liquids and gases in accordance with appropriate NFPA standards.

(e) Control of ignition sources to include smoking, grinding, welding, and cutting. (See NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*.)

(f) Fire prevention surveillance. (See NFPA 601, *Standard on Guard Service in Fire Loss Prevention*.)

(g) Fire report, including an investigation and a statement on the corrective action to be taken (see Appendix A).

### 2-5 Testing, Inspection, and Maintenance.

**2-5.1** Upon installation, all fire protection systems should be preoperationally inspected and tested in accordance with applicable NFPA standards. Where appropriate standards do not exist, inspection and test procedures outlined in the purchase and design specifications should be followed.

**2-5.2** All fire protection systems and equipment should be periodically inspected, tested, and maintained in accordance with applicable *National Fire Codes* (see Table 2-5.2 for guidance).

**Table 2-5.2 Reference Guide for Fire Equipment Inspection, Testing, and Maintenance**

Item	NFPA No.
Supervisory and Fire Alarm Circuits	71 72 26 72H
Fire Detectors	72E 72H
Manual Fire Alarms	71 72H 72
Sprinkler Water Flow Alarms	13A 71 72H 72
Sprinkler and Water Spray Systems	15 13A
Foam Systems	11A 11C 16
Halogenated Agent, Chemical, & CO <sub>2</sub> Systems	12 12A 17 12B
Fire Pumps & Booster Pumps	20
Water Tanks & Alarms	13A 71 22 72
P.L.V.s and O.S. & Y. Valves	13A 26 72H 72
Fire Hydrants and Associated Valves	13A 24 26
Fire Hose and Standpipes	14 1962
Portable Fire Extinguishers & Hose Nozzles	10 1962
Fire Brigade Equipment	1972
Fire Doors	80
Smoke Vents	201M
Emergency Lighting	70
Radio Communication Equipment	1221
Audible and Visual Signals	72 72C

NOTE: Inspection intervals for unattended plants may be extended to normal plant inspections.

**2-5.3** Testing, inspection, and maintenance should be documented with written procedures, results, and follow-up actions recorded.

### 2-6 Impairments.

**2-6.1** A written procedure should be established to address impairments to fire protection systems and other plant systems that impact the level of fire hazard (e.g., dust collection systems, HVAC systems, etc.). As a minimum this procedure should include the following:

- (a) Identify equipment not available for service.
- (b) Identify personnel to be notified (e.g., plant fire brigade chief, public fire department, etc.).
- (c) Increase fire surveillance as needed. [See 2-4(f).]

**2-6.2** Impairment to fire protection systems should be as short in duration as practical. If the impairment is planned, all necessary parts and manpower should be assembled prior to removing the protection system(s) from service. When an impairment is not planned, or when a system has discharged, the repair work or system restoration should be expedited.

**2-6.3** Proper reinstallation after maintenance or repair must be performed to ensure proper systems operation. Once repairs are complete, tests that will ensure proper operation and restoration of full fire protection equipment capabilities should be made. Following restoration to service, the parties previously notified of the impairment should be advised. The latest revision of the design documents reflecting as-built conditions should be available to ensure that the system is properly reinstalled (e.g., drawings showing angles of nozzles).

## 2-7 Fire Emergency Plan.

**2-7.1** A written fire emergency plan should be developed, and, as a minimum, this plan should include the following:

- (a) Response to fire alarms and fire systems supervisory alarms.
- (b) Notification of personnel identified in the plan.
- (c) Evacuation of employees not directly involved in fire fighting activities from the fire area.
- (d) Coordination with security forces or other designated personnel to admit public fire department and control traffic and personnel.
- (e) Fire extinguishment activities.
- (f) Periodic drills to verify viability of the plan.
- (g) Control room operator(s) activities during fire emergencies.

**NOTE**—Emergency conditions may warrant that breathing apparatus be readily available in the control room. Self-contained breathing apparatus should be considered for activities outside the control room.

**2-7.2 Turbine Lubricating Oil Fires.** A critical aspect of responding to turbine lubricating oil fires is minimizing the size and duration of the oil spill. The need for lubrication to protect the turbine-generator bearings and shaft must be balanced against the fire damage from allowing the oil leak to continue. The following steps may be useful in minimizing fire damage and should be considered during preplanning and training for emergency conditions.

- (a) Tripping the turbine.
- (b) Breaking condenser vacuum.
- (c) Emergency purging of the generator.
- (d) Shut down oil pumps.

These actions may cause significant mechanical damage to the turbine. The manufacturer should be consulted for additional guidance. (See Appendix C.)

## 2-8 Fire Brigade.

**2-8.1** The size of the plant and its staff, the complexity of fire fighting problems, and the availability of a public fire department should determine the requirements for a fire brigade.

**2-8.2** If a fire brigade is provided, its organization and training should be identified in written procedures.

**NOTE**—Recommendations contained in NFPA 600, *Standard on Industrial Fire Brigades*, and 29 CFR 1910, Subparts F and L should be consulted for additional information.

**2-8.3** This section discusses special fire fighting conditions unique to fossil fueled steam electric generating plants. This information might be useful in fire brigade training and fire preplanning.

**2-8.3.1 Regenerative Air Heaters.** Since laboratory tests and reported incidents indicated a rapid increase in temperature to the 2800-3000°F (1537-1648°C) range in an air preheater fire, great care should be given to manual fire fighting. Large amounts of water will be needed to both cool and extinguish a preheater fire. Fire preplanning should be accomplished to ensure use of an adequate number of access doors and safe access to the doors.

**2-8.3.2 Electrostatic Precipitators.** Once a fire is detected, the unit should go into emergency shutdown immediately. It should be recognized that during operation the atmosphere in the precipitator is oxygen-deficient and opening doors or running system fans following a fuel trip could cause conditions to worsen (increased potential for backdraft explosion). Once the flow of air and fuel to the fire has been stopped and the electrostatic precipitator has been shut down and deenergized, the precipitator doors may be opened and water hoses employed if necessary.

**2-8.3.3 Cable Trays.** Cable tray fires should be handled like any fire involving energized electrical equipment. It may not be practical or desirable to deenergize the cables involved in the fire. Water is the most effective extinguishing agent for cable insulation fires but must be applied with an electrically safe nozzle. Some cables [polyvinyl chloride (PVC), Neoprene, or Hypalon] can produce dense smoke in a very short time. In addition, PVC liberates hydrogen chloride (HCl) gas. Self-contained breathing apparatus should be used by personnel attempting to extinguish cable tray fires.

**2-8.3.4 Hydrogen System.** Due to the wide explosive limits of hydrogen (4 percent to 75 percent volume of gas in air), under most conditions it is safer to allow a hydrogen fire to burn in a controlled manner until the gas can be shut off rather than to risk an explosion. It may be necessary to extinguish the fire in order to gain access to the shutoff valves.

### 2-8.3.5 Coal Storage and Handling.

**2-8.3.5.1** Once the location and extent of a fire in a coal storage pile has been determined, the coal should be dug out and the heated coal removed. Since moisture accelerates oxidation, water used for fire fighting can aggravate the situation if the seat of the fire is not reached.

**2-8.3.5.2** Clearly marked access panels in equipment should be provided for manual fire fighting. Coal dust presents both a fire and explosion hazard. Combustible, finely divided material is easily ignited. However, there is a possibility that a deep seated hard-to-extinguish fire can occur.

CAUTION: Application of an extinguishing agent that disturbs coal dust deposits could result in a dust explosion.

**2-8.3.6 Coal Pulverizers.** (See NFPA 85C, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boiler-Furnaces*, and NFPA 8503, *Standard for the Installation and Operation of Pulverized Fuel Systems*.)

## Chapter 3 General Plant Design

### 3-1 Plant Arrangement.

#### 3-1.1 Fire Area Determination.

**3-1.1.1** The electric generating plant should be subdivided into separate fire areas as determined by the fire risk evaluation for the purpose of limiting the spread of fire, protecting personnel, and limiting the resultant consequential damage to the plant. Fire areas should be separated from each other by approved fire barriers, spatial separation, or other approved means.

**3-1.1.2** Determination of fire area boundaries should be based on consideration of the following: types, quantity, density, and locations of combustible material; location and configuration of plant equipment; consequence of losing plant equipment; and location of fire detection and suppression systems. It is recommended that most fire barriers separating fire areas be of two hours fire resistance rating. If a fire area is defined as a detached structure, it should be separated from other structures by an appropriate distance [e.g., 30 ft (9.1 m) minimum for a structure with moderate combustible loading and with a non-fire rated enclosure]. Unless consideration of the above factors indicates otherwise, it is recommended that fire area boundaries be provided as follows:

- (a) To separate cable spreading room(s) and cable tunnel(s) from adjacent areas.
- (b) To separate the control room, computer room, or combined control/computer room from adjacent areas. Where the control room and computer room are separated by a common wall, the wall need not have a fire resistance rating.
- (c) To separate rooms with major concentrations of electrical equipment, such as switchgear room and relay room, from adjacent areas.
- (d) To separate battery rooms from adjacent areas.

(e) To separate maintenance shop(s) from adjacent areas.

(f) To separate main fire pump(s) from reserve fire pump(s) where these pumps provide the only source of fire protection water.

(g) To separate fire pumps from adjacent areas.

(h) To separate warehouses from adjacent areas.

(i) To separate emergency diesel generators from each other and from adjacent areas.

(j) To separate fossil fuel-fired auxiliary boiler(s) from adjacent areas.

(k) To separate fuel oil pumping and or fuel oil heating facilities used for continuous firing of the boiler from adjacent areas.

(l) To separate storage areas for flammable and combustible liquid tanks and containers from adjacent areas.

(m) To separate office buildings from adjacent areas.

(n) To separate telecommunication rooms from adjacent areas.

(o) To separate adjacent turbine generators beneath the underside of the operating floor.

**3-1.2 Hydrogen Storage.** Hydrogen storage facilities should be separated from adjacent areas. (See NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, and NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites*.)

#### 3-1.3 Outdoor Oil-Insulated Transformers.

**3-1.3.1** Outdoor oil-insulated transformers should be separated from adjacent structures and from each other by firewalls, spatial separation, or other approved means for the purpose of limiting the damage and potential spread of fire from a transformer failure.

**3-1.3.2** Determination of the type of physical separation should be based on consideration of the following: type and quantity of oil in the transformer, size of a postulated oil spill (surface area and depth), type of construction of adjacent structures, power rating of the transformer, fire suppression systems provided, and type of electrical protective relaying provided.

**3-1.3.3** Unless consideration of the factors in 3-1.3.2 indicates otherwise, it is recommended that any oil-insulated transformer containing 500 gal (1893 L) or more of oil be separated from adjacent noncombustible or limited combustible structures by a 2-hr rated firewall or by spatial separation in accordance with Table 3-1.3.3. Where a firewall is provided between structures and a transformer, it should extend vertically and horizontally as indicated in Figure 3-1.3.3.

NOTE 1: As a minimum, the firewall should extend at least 1 ft (0.31 m) above the top of the transformer casing and oil conservator tank and at least 2 ft (0.61 m) beyond the width of the transformer and cooling radiators.

NOTE 2: If columns for the turbine building roof are protected, line-of-sight protection (see Figure 3-1.3.3) of the fire wall does not need to extend above the operating floor of the turbine building.

**Table 3-1.3.3**  
**Outdoor Oil-Insulated Transformer**  
**Separation Criteria**

Transformer Oil Capacity	Minimum (Line-of-Sight) Separation without Firewall
Less than 500 gal (1893 L)	See 3-1.3.2
500 to 5,000 gal (1893-18,925 L)	25 ft (7.6 m)
over 5,000 gal (18,925 L)	50 ft (15 m)

**3-1.3.4** Unless consideration of the factors in 3-1.3.2 indicates otherwise, it is recommended that adjacent oil-insulated transformers containing 500 gal (1893 L) or more of oil be separated from each other by a 2-hr rated firewall or by spatial separation in accordance with Table 3-1.3.3. Where a firewall is provided between transformers, it should extend at least 1 ft (0.31 m) above the top of the transformer casing and oil conservator tank and at least 2 ft (0.61 m) beyond the width of the transformer and cooling radiators.

**3-1.3.5** Where a firewall is provided, it should be designed to withstand the effects of exploding transformer bushings or lightning arrestors.

NOTE: A higher noncombustible shield may be provided to protect against the effects of an exploding transformer bushing.

**3-1.3.6** Where a firewall is not provided, the edge of the postulated oil spill (i.e., containment basin, if provided) should be separated by a minimum of 5 ft (1.5 m) from the exposed structure to prevent direct flame impingement on the structure.

**3-1.3.7** Outdoor transformers insulated with a less flammable liquid should be separated from each other and from adjacent structures that are critical to power generation by firewalls or spatial separation based on consideration of the factors in 3-1.3.2 and 3-1.3.5.

### 3-1.4 Indoor Transformers.

**3-1.4.1** Dry-type transformers are preferred for indoor installations.

**3-1.4.2** Oil-insulated transformers of greater than 100 gal (379 L) oil capacity installed indoors should be separated from adjacent areas by fire barriers of 3-hr fire resistance rating.

NOTE: Where multiple transformers of less than 100 gal (379 L) capacity each are located within close proximity, additional fire protection may be required based on the fire risk evaluation.

**3-1.4.3** Transformers having a rating greater than 35 kV, insulated with a less flammable liquid or nonflammable fluid and installed indoors should be separated from adjacent areas by fire barriers of 3-hr fire resistance rating.

**3-1.4.4** Where transformers are protected by an automatic fire suppression system, the fire barrier fire resistance rating may be reduced to 1 hr.

### 3-1.5 Openings in Fire Barriers.

**3-1.5.1** All openings in fire barriers should be provided with fire door assemblies, fire dampers, penetration seals (fire stops), or other approved means having a fire protection rating consistent with the designated fire resistance rating of the barrier. Windows in fire barriers (e.g., control rooms or computer rooms) should be provided with a fire shutter or automatic water curtain. Penetration seals provided for electrical and piping openings should be listed or should meet the requirements for an "F" rating when tested in accordance with ASTM E814, *Fire Tests of Through-Penetration Fire Stops*. Other test methods for qualifications of penetration seals, such as IEEE 634, *Testing of Fire Rated Penetration Seals*, may be considered for this application.

NOTE: Listed penetration seals for large diameter piping may not be commercially available. In such instances the design should be similar to listed configurations.

**3-1.5.2** Fire door assemblies, fire dampers, and fire shutters used in 2-hr rated fire barriers should be rated not less than 1½ hr (see NFPA 80, *Standard for Fire Doors and Windows*).

### 3-2 Life Safety.

**3-2.1** For life safety for electric generating plants included in the scope of this document see NFPA 101, *Life Safety Code*.<sup>8</sup>

**3-2.2** Structures should be classified as follows, as defined in NFPA 101:

(a) General areas should be considered as a special purpose industrial occupancy.

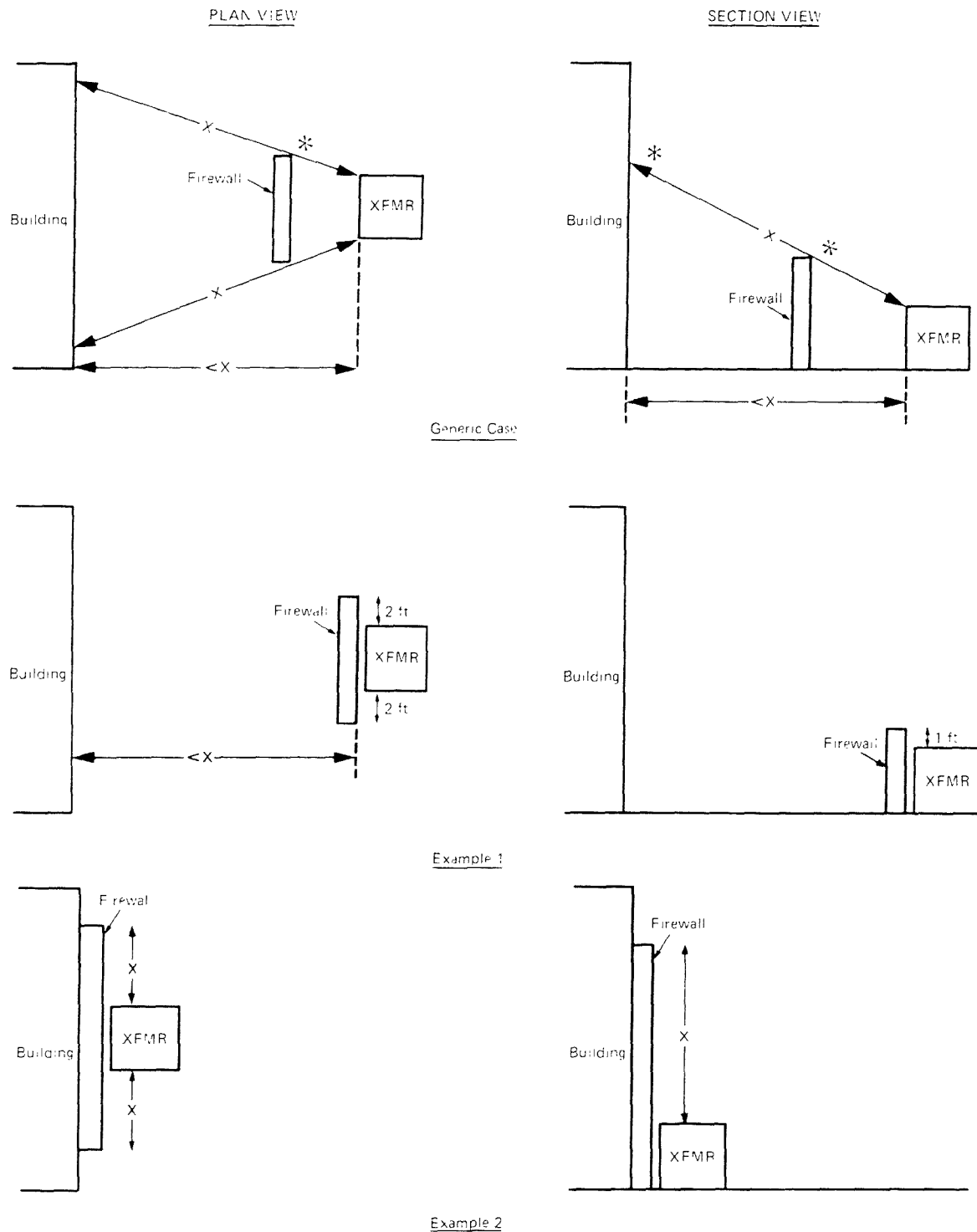
NOTE 1: It generally is recognized that boiler and turbine buildings meet the intent of NFPA 101, *Life Safety Code*, for additional travel distances.

NOTE 2: NFPA 101 excludes normally unoccupied spaces from the means of egress considerations of the code. These areas may be provided with fixed industrial stairs, fixed ladders (see ANSI 114.3, *Standard for Safety Requirements for Fixed Ladders*), or alternating tread devices (see NFPA 101). Examples of normally unoccupied spaces include:

(a) Catwalks, floor areas, or elevated platforms that are provided for maintenance and inspection of in-place equipment, or

(b) The enclosure around individual packaged combustion turbines, units, or other similar equipment enclosures.

(b) Open structures and underground structures (e.g., tunnels) should be considered as occupancies in special structures.

Notes

X = Minimum separation distance from Table 3-1.3.3

\* Also see Note in 3-1.2.3

For SI Units: 1 ft = 0.305 m

Figure 3-1.3.3.

(c) General office structures should be considered as a business occupancy.

(d) Warehouses should be considered as a storage occupancy.

(e) Coal preparation buildings (e.g., enclosed crusher houses) should be considered high hazard occupancies.

### 3-3 Building Construction Materials.

**3-3.1** Construction materials being considered for electric generating plants should be selected based on the fire risk evaluation and on consideration of the following NFPA standards:

(a) NFPA 220, *Standard on Types of Building Construction*.

(b) NFPA 251, *Standard Methods of Fire Tests of Building Construction and Materials*.

(c) NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*.

(d) NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*.

(e) NFPA 259, *Standard Test Method for Potential Heat of Building Materials*.

**3-3.2** Construction materials used in the boiler or turbine-generator buildings or other buildings critical to power generation should meet the definition of noncombustible or limited combustible, except roof coverings, which should be as outlined in 3-3.3, and except for limited use of translucent reinforced plastic panels as allowed by the fire risk evaluation.

**3-3.3** Roof covering should be Class A in accordance with NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*. Metal roof deck construction, where used, should be "Class I" or "fire classified."

### 3-3.4 Interior Finish.

**3-3.4.1** Cellular or foamed plastic materials (as defined in Appendix A of NFPA 101, *Life Safety Code*) should not be used as interior finish.

**3-3.4.2** Interior finish in buildings critical to power generation should be Class A.

**3-3.4.3** Interior finish in buildings not critical to power generation should be Class A or Class B.

### 3-4 Smoke and Heat Venting, Heating, Ventilating, and Air Conditioning.

#### 3-4.1 Smoke and Heat Venting.

**3-4.1.1 General.** Smoke and heat vents are not substitutes for normal ventilation systems unless designed for dual usage. They should not be used to assist such systems for comfort ventilation. They should not be left open where they can sustain damage from high wind conditions. They should be included in surveillance programs to assure availability in emergency situations.

##### 3-4.1.2 Heat Vents.

**3-4.1.2.1** Heat vents should be provided for areas identified by the fire risk evaluation. Where heat vents are provided, heat generated under fire conditions should be vented from its place of origin directly to the outdoors.

**3-4.1.2.2** Heat vents in the boiler and turbine building may be provided through the use of automatic heat vents or windows at the roof eave line. Heat venting in areas of high combustible loading can reduce damage to structural components. (See NFPA 204M, *Guide for Smoke and Heat Venting*.)

##### 3-4.1.3 Smoke Vents.

**3-4.1.3.1** Smoke venting should be provided for areas identified by the fire risk evaluation. Where smoke venting is provided, smoke should be vented from its place of origin in a manner that does not interfere with the operation of the plant.

**3-4.1.3.2** Separate smoke ventilation systems are preferred; however, smoke venting can be integrated into normal ventilation systems using automatic or manually positioned dampers and motor speed control. (See NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*; NFPA 92A, *Recommended Practice for Smoke Control Systems*; and NFPA 204M, *Guide for Smoke and Heat Venting*.) Smoke venting may also be accomplished through the use of portable smoke ejectors.

**3-4.1.3.3** Consideration should be given to smoke venting for the following areas: control room, cable spreading room(s), and switchgear room.

**3-4.1.3.4** In the areas with gaseous fire extinguishing systems, the smoke ventilation system should be properly interlocked to assure the effective operation of the gaseous fire extinguishing system.

**3-4.1.3.5** Smoke removal system dampers, where installed, normally are operable only from an area immediately outside of, or immediately within, the fire area served since it is desired to have entry into, and inspection of, the fire area by fire fighting personnel prior to restoring mechanical ventilation to the fire area. Smoke removal system dampers may be operable from the control room if provisions are made to prevent premature operation. This can be accomplished using thermal interlocks or administrative controls.

**3-4.1.3.6** The fan power supply wiring and controls for smoke exhaust should be located external to the fire area served by the fan or be installed in accordance with the fire risk evaluation.

#### 3-4.2 Normal Heating, Ventilating, and Air Conditioning Systems.

**3-4.2.1** For normal heating, ventilating, and air conditioning systems, see NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, or NFPA 90B, *Standard for the Installation of Warm Air Heating and Air Conditioning Systems*, as appropriate.

**3-4.2.2** Air conditioning for the control room should provide a pressurized environment to preclude the entry of smoke in the event of a fire outside the control room.

**3-4.2.3** Plastic ducts, including listed fire retardant types, should not be used for ventilating systems. Listed plastic fire retardant ducts with appropriate fire protection may be used in areas with corrosive atmospheres.



**3-4.2.4** Fire dampers (doors) compatible with the rating of the barrier should be provided at the duct penetrations to the fire area (see Section 3-1) unless the duct is protected throughout its length by a fire barrier equal to the rating required of fire barrier(s) penetrated.

**3-4.2.5** Smoke dampers, where installed, should be installed in accordance with NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*.

**3-4.2.6** The fresh air supply intakes to all areas should be located remotely from the exhaust air outlets and smoke vents of other fire areas to minimize the possibility of drawing products of combustion into the plant.

### 3-5 Drainage.

**3-5.1** Provisions should be made in all fire areas of the plant for removal of all liquids directly to safe areas or for containment in the fire area without flooding of equipment and without endangering other areas. (See Appendix A of NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*.) Drainage and prevention of equipment flooding should be accomplished by one or more of the following:

- (a) Floor drains.
- (b) Floor trenches.
- (c) Open doorways or other wall openings.
- (d) Curbs for containing or directing drainage.
- (e) Equipment pedestals.
- (f) Pits, sumps, and sump pumps.

**3-5.2** The provisions for drainage and any associated drainage facilities should be sized to accommodate all of the following:

- (a) The spill of the largest single container of any flammable or combustible liquids in the area.
- (b) The maximum expected number of fire hose lines [500 gpm (31.5 L/sec) minimum] operating for a minimum of 10 minutes.
- (c) The maximum design discharge of fixed fire suppression systems operating for a minimum of 10 minutes.

NOTE: Design discharge for the turbine building should be based on the expected time necessary to take the turbine off line and put it on turning gear, but not less than 10 minutes.

**3-5.3** The drainage system for continuous fuel oil-fired boilers should consist of curbs and gutters arranged to confine the area of potential fuel oil discharge. Consideration also should be given to providing the same measures for coal-fired boilers using oil for ignition. Walking surfaces in the vicinity of burners should be made impervious to oil leakage by the use of checkered steel plate, sheet metal drip pans, or other means. Curbs in passageways should have ramps or steps or be otherwise constructed to present no obstacle to foot traffic. Gutter outlet pipes and all other drains should be trapped to prevent the passage of flames and permit the flow of oil. A clearance between the boiler front and the walk structure is required for the differential movement when the heated boiler elongates. This clearance space in the vicinity of the burners should be flashed

and counter-flashed with sheet metal or otherwise arranged to allow movement and to redirect dripping oil, which may impinge on the boiler face.

**3-5.4** Floor drainage from areas containing flammable or combustible liquids should be trapped to prevent the spread of burning liquids beyond the fire area.

**3-5.5** Where gaseous fire suppression systems are installed, floor drains should be provided with adequate seals or the fire suppression system should be sized to compensate for the loss of fire suppression agent through the drains.

**3-5.6** Drainage facilities should be provided for outdoor oil-insulated transformers, or the ground should be sloped such that oil spills will flow away from buildings, structures, and adjacent transformers. Unless drainage from oil spills is accommodated by sloping the ground around transformers away from structures or adjacent equipment, consideration should be given to providing curbed areas or pits around transformers. The pit or drain system or both should be sized in accordance with 3-5.2. If a layer of uniformly graded stone is provided in the bottom of the curbed area or pit as a means of minimizing ground fires, the following should be addressed:

- (a) Sizing of the pit should allow for the volume of the stone.
- (b) The design should address the possible accumulation of sediment or fines in the stone.

**3-5.7** For facilities consisting of more than one generating unit, a curb or trench drain should be provided on solid floors where the potential exists for an oil spill, such that oil released from an incident on one unit will not expose an adjacent unit.

**3-5.8** For environmental reasons, liquid discharges resulting from oil spills or operation of a fire suppression system may have to be treated (e.g., oil separation).

### 3-6 Emergency Lighting.

**3-6.1** Emergency lighting should be provided for means of egress (see NFPA 101, *Life Safety Code*).

**3-6.2** Emergency lighting should be provided for critical plant operations areas.

**3-7 Lightning Protection.** Lightning protection should be provided for those structures having a risk index (R) of four or greater when evaluated in accordance with NFPA 780, *Lightning Protection Code*.

## Chapter 4 General Fire Protection Systems and Equipment

**4-1 General.** All fire protection systems, equipment, and installations should be dedicated to fire protection purposes.

## 4-2 Water Supply.

**4-2.1** The water supply for the permanent fire protection installation should be based on providing a 2-hr supply for both items (a) and (b) as follows:

(a) Either of items (i) or (ii) below, whichever is larger:

(i) The largest fixed fire suppression system demand.

(ii) Any fixed fire suppression system demands that could reasonably be expected to operate simultaneously during a single event [e.g., turbine under floor protection in conjunction with other fire protection system(s) in the turbine area; coal conveyor protection in conjunction with protection for related coal handling structures during a conveyor fire; adjacent transformers not adequately separated according to 3-1.3].

(b) The hose stream demand of not less than 500 gpm (31.5 L/sec).

**4-2.2** Where an adequate and reliable water supply, such as a lake, cooling pond, river, or municipal water system, is unavailable, at least two separate water supplies should be provided for fire protection purposes with each supply capable of meeting the fire water flow requirements determined by 4-2.1.

**4-2.3** Each water supply should be connected to the yard main by separate connections arranged and valve controlled to minimize the possibility of multiple supplies being impaired simultaneously.

**4-2.4** In some rivers and tributaries the existence of microorganisms limits the use of raw water for fire protection without treatment. Consideration of water quality may prevent long-term problems relating to fire protection water supply.

## 4-2.5 Fire Pumps.

**4-2.5.1** Where multiple fire pumps are required, the pumps should not be subject to a common failure, electrical or mechanical, and should be of sufficient capacity to meet the fire flow requirements determined by 4-2.1 with the largest pump out of service.

**4-2.5.2** Fire pumps should be automatic starting with manual shutdown. The manual shutdown should be at the pump controllers only. (*See NFPA 20, Standard for the Installation of Centrifugal Fire Pumps.*)

## 4-2.6 Water Supply Tanks.

**4-2.6.1** If tanks are of dual-purpose use, a standpipe or similar arrangement should be provided to dedicate the amount determined by 4-2.1 for fire protection use only. (*See NFPA 22, Standard for Water Tanks for Private Fire Protection.*)

**4-2.6.2** Where tanks are used, they should be filled from a source capable of replenishing the 2-hr supply for the fire protection requirement in an 8-hr period. The 8-hr (time) requirement for refilling may be extended if the initial supply exceeds the minimum storage requirement on a volume per time ratio basis. It normally is preferred for the refilling operation to be accomplished on an automatic basis.

**4-3 Valve Supervision.** All fire protection water supply and system control valves should be under a periodic inspection program (*see Chapter 2*) and should be supervised by one of the following methods:

(a) Electrical supervision with audible and visual signals in the main control room or another constantly attended location.

(b) Locking valves open. Keys should be made available only to authorized personnel.

(c) Sealing of valves. This option should be followed only when valves are within fenced enclosures under the control of the property owner.

## 4-4 Yard Mains, Hydrants, and Building Standpipes.

### 4-4.1 Yard Mains and Hydrants.

**4-4.1.1** Yard mains and outdoor fire hydrants should be installed on the plant site. (*See NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*)

**4-4.1.2** Remotely located plant-related facilities should be reviewed on an individual basis to determine the need for fire protection. If excessively long extensions of underground fire mains are necessary for fire protection at these locations, it may be acceptable to supply this need from an available service main in the immediate area. Where common supply piping is provided for service water and fire protection water supply, it should be sized to accommodate both service water and fire protection demands.

**4-4.1.3** The supply mains should be looped around the main power block and should be of sufficient size to supply the flow requirements determined by 4-2.1 to any point in the yard loop considering the most direct path to be out of service. Pipe sizes should be designed to encompass any anticipated expansion and future water demands.

**4-4.1.4** Indicator control valves should be installed to provide adequate sectional control of the fire main loop to minimize plant protection impairments.

**4-4.1.5** Each hydrant should be equipped with a separate shutoff valve located on the branch connection to the supply main.

**4-4.1.6** Interior fire protection loops are considered an extension of the yard main and should be provided with at least two valved connections to the yard main with appropriate sectional control valves on the interior loop.

### 4-4.2 Standpipe and Hose Systems.

**4-4.2.1** Standpipe and hose systems should be installed (*see NFPA 14, Standard for the Installation of Standpipe and Hose Systems*). The standpipe and hose system is an extension of the yard fire main and hydrant system. The hose stations should be capable of delivering the hose stream demand for the various hazards in buildings.

**4-4.2.2** Fire main connections for standpipes should be arranged so that a fire main break may be isolated without interrupting service simultaneously to both fixed protection and hose connections protecting the same hazard or

area. Choice of Class I, II, or III systems should be by fire risk evaluation (see NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*).

**4-4.2.3** The standpipe piping should be capable of providing minimum volume and pressure for the highest hose stations.

**4-4.2.4** Due to the open arrangement of these plants, locations of hose stations should take into account safe egress for personnel operating hose lines.

**4-4.3 Hose Nozzles.** Spray nozzles having shutoff capability and listed for use on electrical equipment should be provided on hoses located in areas near energized electrical equipment.

**4-4.4 Hose Threads.** Hose threads on hydrants and standpipe systems should be compatible with fire hose used by the responding fire departments.

**4-5 Portable Fire Extinguishers.** Portable fire extinguishers should be provided (see NFPA 10, *Standard for Portable Fire Extinguishers*).

#### **4-6 Fire Suppression Systems and Equipment — General Requirements.**

**4-6.1** Fire suppression systems and equipment should be provided in all areas of the plant as identified in Chapters 5, 6, and 7 or as determined by the fire risk evaluation. Fixed suppression systems should be designed in accordance with the following codes and standards unless specifically noted otherwise:

NFPA 11, *Standard for Low Expansion Foam and Combined Agent Systems*

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*

NFPA 13, *Standard for the Installation of Sprinkler Systems*

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*

NFPA 16, *Standard on the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*

NFPA 231, *Standard for General Storage*

NFPA 231C, *Standard for Rack Storage of Materials*.

**4-6.2** Selection of an extinguishing agent or a combination of extinguishing agents should be based on:

(a) Type of hazard.

(b) Effect of agent discharge on equipment.

(c) Health hazards.

#### **4-6.3 Fire Suppression System Safety Considerations.**

**4-6.3.1** It is imperative that safety in the use of any fire suppression system be given proper consideration and that adequate planning be done to ensure safety of personnel.

**4-6.3.2** Potential safety hazards could include impingement of high velocity discharge on personnel, loss of visibility, hearing impairment, reduced oxygen levels that will not support breathing, toxic effects of the extinguishing agent, breakdown products of the extinguishing agent, and electric conductivity of water-based agents.

**4-6.3.3** When working in areas (e.g., combustion turbine compartments) where egress is difficult, the fire extinguishing system should be provided with an isolation (inhibit) switch to prevent discharge of the system. A trouble indication should be provided when the system is in the "inhibit" mode.

**4-6.3.4** NFPA standards for the extinguishing systems used should be carefully studied and the personnel safety provisions followed. Evacuation of a protected area is recommended before any special extinguishing system discharges. Alarm systems that are audible above machinery background noise, or that are visual or olfactory or a combination, should be used where appropriate. Personnel warning signs are necessary.

#### **4-7 Fire Signaling Systems.**

**4-7.1** Fire detection and automatic fixed fire suppression systems should be equipped with local audible and visual signals with annunciation in the main control room or another constantly attended location (see NFPA 72, *Standard for the Installation, Maintenance, and Use of Protective Signaling Systems*, and NFPA 72G, *Guide for the Installation, Maintenance, and Use of Notification Appliances for Protective Signaling Systems*). Audible fire alarms should be distinctive from other plant system alarms.

**4-7.2** Fire detection and automatic fixed-fire suppression systems should be equipped with local audible and visual signals with annunciation in the main control room or another constantly attended location. Audible fire alarms should be distinctive from other plant system alarms.

**4-7.3** Automatic fire detectors should be installed in accordance with NFPA 72E, *Standard on Automatic Fire Detectors*.

**4-7.4** The fire signaling system or plant communication system should provide the following:

(a) Manual fire alarm devices (e.g., pull boxes or page party stations) installed in all occupied buildings. Manual fire alarm devices should be installed for remote yard hazards as identified by the fire risk evaluation.

(b) Plant-wide audible fire alarm and/or voice communication systems for purposes of personnel evacuation and alerting of plant emergency organization. The plant public address system, if provided, should be available on a priority basis.

- (c) Two-way communications for the plant emergency organization during emergency operations.
- (d) Means to notify the public fire department.

## Chapter 5 Identification of and Protection against Hazards

**5-1 General.** The identification and selection of fire protection systems should be based on the fire risk evaluation. This chapter identifies fire and explosion hazards in fossil fueled electric generating stations and specifies the recommended protection criteria unless the fire risk evaluation indicates otherwise.

### 5-2 Fuel Handling — Gas.

**5-2.1** The storage and associated piping systems for gases in the gaseous or liquefied states should comply with NFPA 54, *National Fuel Gas Code*; NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*; and ANSI B31.1, *Code for Power Piping*.

**5-2.2** Electrical equipment in areas with potentially hazardous atmospheres should be designed and installed in compliance with Articles 500 and 501 of NFPA 70, *National Electrical Code*,<sup>1</sup> and ANSI C2, *National Electrical Safety Code*.

### 5-3 Fuel Handling — Oil.

**5-3.1** Fuel oil storage, pumping facilities, and associated piping should comply with NFPA 30, *Flammable and Combustible Liquids Code*; NFPA 31, *Standard for the Installation of Oil Burning Equipment*; and ANSI B31.1 *Code for Power Piping*.

**5-3.2** Internal tank heaters needed to maintain oil pumpability should be equipped with temperature sensing devices that alarm in a constantly attended area prior to overheating of the oil.

**5-3.3** External tank heaters should be interlocked with a flow switch to shut off the heater if oil flow is interrupted.

**5-3.4** Tank filling operations should be monitored to prevent overfilling.

**5-3.5** While oil unloading operations are in progress, the unloading area should be manned by personnel properly trained in the operation of pumping equipment, valving, and firesafety.

**5-3.6** Pump installations should not be located within tank dikes.

**5-3.7** Electrical equipment in areas with potentially hazardous atmospheres should be designed and installed in compliance with NFPA 30, *Flammable and Combustible Liquids Code*; Articles 500 and 501 of NFPA 70, *National Electrical Code*; and ANSI C2, *National Electrical Safety Code*.

**5-3.8** To prevent hazardous accumulations of flammable vapors, ventilation for indoor pumping facilities for flammable liquids should provide at least 1 cu ft of exhaust air per sq ft of floor area (0.30 m<sup>3</sup>/m<sup>2</sup>), but not less than 150 cu ft per min (0.07 l/m<sup>3</sup>/sec).

### 5-3.9 Fire Protection.

**5-3.9.1** Indoor fuel oil pumping and/or heating facilities should be protected with automatic sprinklers, water spray, foam-water sprinklers, or gaseous total flooding system(s). Local application dry chemical systems may be used in areas that normally do not have reignition sources, such as steam lines or hot boiler surfaces.

**5-3.9.2** The provision of foam systems for tank protection should be considered in the fire risk evaluation with consideration of exposure to other important structures, product value, and resupply capability.

**5-3.9.3** Fuel oil handling and storage areas should be provided with hydrant protection in accordance with Section 4-4.

### 5-4 Fuel Handling — Coal.

#### 5-4.1 Storage.

**5-4.1.1** Coal storage piles are subject to fires caused by spontaneous heating of the coal. The coals most susceptible to self-heating are those with high pyritic content and high intrinsic moisture and oxygen content, such as low-rank coals. The mixing of high pyritic coals with high moisture and oxygen coals increases self-heating.

**5-4.1.2** There are measures that can be taken to lessen the likelihood of coal pile fires. These measures are dependent on the type and rank of coal. Among the more important are:

(a) Short duration, active, or "live" storage piles should be worked to prevent dead pockets of coal, a potential source of spontaneous heating.

(b) Coal piles should not be located above sources of heat, such as steam lines, or sources of air, such as man-holes.

(c) Coal placed in long-term storage should be piled in layers, appropriately spread, and compacted prior to the addition of subsequent layers to reduce air movement and to minimize water infiltration into the pile.

(d) Different types of coal that are not chemically compatible should not be stored in long-term storage piles.

(e) Access to coal storage piles should be provided for fire fighting operations and for pulling out hot pockets of coal.

**5-4.2 Bins, Bunkers, and Silos.** The recommendations of this section should be considered to reduce the probability of serious fire. (See NFPA 850<sup>2</sup>, *Standard for Pulverized Fuel Systems*.)

**5-4.2.1** Storage structures should be of noncombustible construction and designed to minimize corners or pockets that cause coal to remain trapped and present a potential for spontaneous combustion.

**5-4.2.2** During planned outages, coal bins, bunkers, or silos should be emptied to the extent practical.

**5-4.2.3** The period of shutdown requiring emptying of the bins depends on the spontaneous heating characteristics of the coal. However, spontaneous heating can be slowed by minimizing air flow through the bins by such means as inerting or filling the bins with high-expansion foam.

**5-4.2.4** Once spontaneous heating develops to the fire stage it becomes very difficult to extinguish the fire short of emptying the bin, bunker, or silo. Therefore, provisions for emptying the bunker should be provided. This may take the form of conveyors discharging to a stacking out pile. Another method would use flanged openings for removing the coal if adequate planning and necessary equipment have been provided. Removing hot or burning coal can lead to a dust explosion if a dust cloud develops. Therefore, means should be provided to prevent a dust cloud, such as covering the coal with a blanket of high-expansion foam.

**5-4.2.5** Care should be taken when working in enclosed areas near coal bins, bunkers, or silos in confined areas since spontaneous heating of coal can generate gases that are both toxic and explosive. Fixed or portable carbon monoxide monitoring should be provided to detect spontaneous heating and hazardous conditions.

**5-4.2.6** Dusttight barriers should be provided between the boiler house and the areas of the coal handling system above the bin, bunker, or silo.

### 5-4.3 Dust Suppression and Control.

**5-4.3.1** Coal dust generated due to coal handling constitutes a fire and explosion hazard that should be controlled by one or more of the following methods:

- (a) Dust collection system
- (b) Dust suppression system
- (c) Open-air construction.

**5-4.3.2** Where dust collection or suppression systems are installed to prevent hazardous dust concentration, appropriate electrical and mechanical interlocks should be provided to prevent the operation of coal handling systems prior to the starting and sustained operation of the dust control equipment.

NOTE: Constructing enclosure hoods at transfer points can minimize the amount of dust released to surrounding areas, which may reduce the need for dust collection.

**5-4.3.3** Dust suppression systems usually consist of spray systems using water and/or surfactants to reduce the dust generation of coal handling operations. The sprays are normally applied at or near those locations where the coal is transferred from one conveyor to another.

**5-4.3.4** For dust collection systems provided for handling combustible dusts, see NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*. Other recommendations for reducing the probability of explosion and fire from coal dust are:

- (a) Fans for dust collectors should be installed downstream of the collectors so that they handle only clean air.

- (b) For dust collectors vented to the outside see NFPA 68, *Guide for Venting of Deflagrations*. Explosion suppression systems may be provided for dust collection systems that cannot be safely vented to the outside. (See NFPA 69, *Standard on Explosion Prevention Systems*.)

- (c) Dust collection hoppers should be emptied prior to shutting down dust removal systems to reduce the likelihood of collector fires originating from spontaneous heating in the dust hopper.

- (d) High level detection with annunciator alarm should be provided for the dust hoppers.

**5-4.3.5** Cleaning methods such as vigorous sweeping of dust or blowing down with steam or compressed air should not be used since these methods can produce an explosive atmosphere. Preferred cleaning methods would use appropriate portable or fixed pipe vacuum cleaners of a type approved for dust hazardous locations or low velocity water spray nozzles and hose.

### 5-4.4 Coal Conveyors.

**5-4.4.1** Coal conveyor belts should be of material designed to resist ignition. U.S. Mine Safety and Health Administration and Canadian Bureau of Mines Standards for fire retardant conveyor belt materials should be used as a guide. However, "fire retardant" belt materials will burn and therefore may require additional fire protection.

**5-4.4.2** Each conveyor system should be arranged to automatically shut off driving power in the event of belt slowdown of greater than 20 percent or misalignment of belts. In addition, a complete belt interlock shutdown system should be provided so that, if any conveyor stops, the power to all conveyor systems feeding that belt would be shut down automatically.

**5-4.4.3** Hydraulic systems should use only listed fire retardant hydraulic fluids. Where unlisted hydraulic fluids must be used, consideration should be given to protection by a fire suppression system.

**5-4.4.4** Foreign materials pose a threat to crushers, pulverizers, and feeders by interrupting the flow of coal or by causing sparks capable of igniting coal dust air mixtures. Methods of removing tramp metals and other foreign materials include magnetic separators, pneumatic separators, and screens. Means for removing such foreign material should be provided as early in the coal handling process as possible.

### 5-4.5 Coal Conveying and Handling Structures.

**5-4.5.1** Coal conveying and handling structures and supports should be of noncombustible construction.

**5-4.5.2** The accumulation of coal dust in enclosed buildings can be reduced by designing structural members such that their shape or method of installation minimizes the surface area on which dust can settle. Consideration should be given to installing structural members exterior to the enclosure. Access should be provided to facilitate cleaning of all areas.

**5-4.5.3** For explosion venting for enclosed structures see NFPA 68, *Guide for Venting of Deflagrations*.

**5-4.5.4** Provision should be made for deenergizing both lighting and electrical power circuits without requiring personnel to enter dust-producing sections of the plant during emergencies.

**5-4.5.5** Areas of the coal handling system requiring heat should use approved heaters suitable for hazardous areas. The heating equipment should be kept free of dusts and should be designed to limit surface temperature to 329°F (165°C).

**5-4.5.6** Electrical equipment within coal handling areas should be approved for use in hazardous locations Class II, Division 1 or Division 2, Group F. Electrical equipment subject to accumulations of methane gas or carbon monoxide should also be listed and installed, as appropriate, for use in hazardous locations Class I, Division 2, Group D. (See Articles 500 and 501 of NFPA 70, *National Electrical Code*, and Section 127 of ANSI C.2, *National Electrical Safety Code*.)

NOTE: Under some unusual conditions coal dust may need to be treated as Class II, Group E or G, due to its resistivity.

**5-4.5.7** Static electricity hazards should be minimized by the permanent bonding and grounding of all equipment, including duct work, conveyor drive belts, pulleys, idlers, take-up reels, motor drives, dust collection equipment, and vacuum cleaning equipment. (See NFPA 77, *Recommended Practice on Static Electricity*.)

## 5-4.6 Fire Protection.

**5-4.6.1** Automatic sprinkler or water spray systems should be provided for coal handling structures that are critical to power generation and subject to accumulations of coal or coal dust. Sprinkler systems should be designed for a minimum of 0.25 gpm per sq ft (0.17 L sec-m<sup>2</sup>) density over a 2500 sq ft (232 m<sup>2</sup>) area. If water spray systems are used to protect structures, the same densities should be used.

**5-4.6.2** Automatic water spray or sprinkler systems should be provided for enclosed coal conveyors that are critical to continuous power generation. Sprinklers should be designed for a minimum of 0.25 gpm-ft<sup>2</sup> (0.17 L sec-m<sup>2</sup>) density over 2,000 sq ft (186 m<sup>2</sup>) of enclosed area or the most remote 100 linear ft (30 m) of conveyor structure up to 2,000 sq ft (186 m<sup>2</sup>). For water spray design criteria see NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*.

**5-4.6.2.1** If a sprinkler system is used to protect the coal conveyor, particular care must be exercised in locating closed sprinkler heads so that they will be in the path of the heat produced by the fire and still be in a position to provide good coverage of all belt surfaces along the conveyor.

**5-4.6.2.2** Conveyors that are below grade or enclosed are extremely hazardous to maintenance or fire fighting personnel in the event of a fire. Automatic water spray or sprinkler systems should be provided for these conveyors even though they may not be critical to plant operations.

**5-4.6.2.3** Actuation of water spray or sprinkler systems should shut down the conveyor belt involved and all conveyor belts feeding the involved belt.

**5-4.6.2.4** Dust collectors and fans should automatically shut down along with other related equipment upon detection of fire.

**5-4.6.2.5** Draft barriers installed at the end and mid-points of enclosed conveyors should be considered in the fire risk evaluation. Draft barriers will reduce the response time of installed automatic sprinkler or detection systems and minimize the chimney effects in the event of fire.

**5-4.6.3** Stacker-reclaimer and barge ship unloader conveyors present unique fire protection concerns. Protection of the equipment and safety of the personnel is made more difficult due to the movement-in-place capabilities of the equipment and its mobility and movement along a fixed rail system. Provision of hydrants "in the area" may not be sufficient protection primarily due to the extreme delay in response in the event of fire emergency and the difficulty in reaching all areas involved in a fire with hand-held hose equipment.

**5-4.6.4** Consideration should be given to the installation of an automatic water spray or sprinkler system over the conveyor belt and striker plate areas within the stacker-reclaimer. Water supply could be from a 3000 to 5000 gal (11,355 to 18,925 L) capacity pressure tank located on-board. A fire department pumper connection should be provided so connection can be made to the fire hydrants in the area during down or repair periods to provide a more adequate water supply. Consideration should be given to protecting enclosed electrical control cabinets by a preengineered fixed automatic gaseous-type suppression system activated by a fixed temperature detection system.

**5-4.6.5** Bag-type coal dust collectors that are located inside buildings or structures should be protected with automatic sprinkler or water spray systems inside of the collectors.

**5-4.6.5.1** Sprinklers for bag-type dust collectors should be designed for ordinary hazard systems. Sprinkler and water spray systems should be designed for a density of 0.20 gpm (0.013 L/sec) over the projected plan area of the dust collector.

**5-4.6.5.2** Protection inside dust collectors should include the clean air plenum and the bag section. If the hopper is shielded from water discharge, sprinklers also should be provided in the hopper section.

**5-4.6.5.3** Consideration should be given to provide automatic sprinkler systems for bag-type dust collectors located outdoors that:

- (a) Are in continuous operation.
- (b) Process large amounts of coal dust.
- (c) Have limited access for manual fire fighting. An example of limited access would be collectors that have catwalks for access.

**5-5 Steam Generator.** For boiler-furnaces see NFPA 8501, *Standard for Single Burner Boiler Operation*, and NFPA 85C, *Standard for the Prevention of Furnace Explosions Implosions in Multiple Burner Boiler-Furnaces*.

### 5-5.1 Fire Protection.

**5-5.1.1** Boiler-furnaces with multiple oil-fired burners or using oil for ignition should be protected with automatic sprinkler, water spray, foam, or foam-water sprinkler systems covering the burner front oil hazard.

**5-5.1.2** Boiler front fire protection systems should be designed to cover the fuel oil burners and ignitors, adjacent fuel oil piping and cable, a 20 ft (6.1 m) distance from the burner and ignitor including structural members and walkways at these levels. Additional coverage should include areas where oil may collect. Sprinkler and water spray systems should be designed for a density of 0.25 gpm/ft<sup>2</sup> (0.17 L/sec-m<sup>2</sup>) over the protected area.

### 5-5.2 Pulverizers.

**5-5.2.1** For pulverized fuel systems see NFPA 8503, *Standard for Pulverized Fuel Systems*.

**5-5.2.2** Carbon monoxide gas detection systems should be considered for pulverizers as an early warning for conditions leading to fires and explosions.

### 5-5.3 Boiler Feed Pumps.

**5-5.3.1** Coverage of steam-driven boiler feed pumps should include oil lubrication lines, bearings, and oil reservoirs. Accidental water discharge on bearing points and hot turbine parts should be considered. If necessary these areas may be protected by shields and casing insulation with metal covers. Boiler feed pumps that are electric motor-driven, with lubricating or hydraulic oil hazards, may require protection depending on the quantity of oil, oil pressure, or exposure to other equipment.

**5-5.3.2** Hydraulic and lubricating oil hazards associated with boiler feed pumps that are driven with steam turbines should be protected in accordance with 5-7.4.1.

**5-5.3.3** Curbing or drainage or both should be provided for the steam-driven boiler feed pump oil reservoirs in accordance with Section 3-5.

## 5-6 Flue Gas.

### 5-6.1 Forced Draft, Induced Draft, and Flue Gas Recirculation Fans.

**5-6.1.1** Coverage of steam-driven fans should include oil lubrication lines, bearings, and oil reservoirs. Accidental water discharge on bearing points and hot turbine parts should be considered. If necessary, these areas may be protected by shields and casing insulation with metal covers. Water spray systems for steam turbine-driven forced draft and induced draft fans should be designed for a density of 0.25 gpm/ft<sup>2</sup> (0.17 L/sec-m<sup>2</sup>) over the oil containment equipment surface. Water spray systems should be designed for 0.25 gpm/ft<sup>2</sup> (0.17 L/sec-m<sup>2</sup>) for a minimum 20 ft (6.1 m) from the hazard. Combustible oil hazards associated with forced and induced draft fans driven with steam turbines should be protected with automatic sprinkler, water spray, or foam-water sprinkler systems.

**5-6.1.2** Forced draft fans, induced draft fans, and flue gas recirculation fans should use a listed fire resistant fluid for hydraulic drives. Where nonapproved hydraulic fluids are used, protection should be provided as described in 5-6.1.1.

### 5-6.2 Regenerative Air Heaters.

**5-6.2.1** Fires have occurred in air heaters after the accumulation of appreciable quantities of unburned combustibles on plate surfaces resulting from incomplete combustion of fuel in the boiler. Incomplete combustion is most likely to occur during startup. Incomplete combustion also can occur during load changes, periods of low firing rate, or normal operation due to unstable or over-rich firing.

**5-6.2.2** Fire-loss experience does not presently indicate the need for special protection for other than regenerative-type air heaters. Regenerative-type air heater fires have occurred when firing on all types of fuel. Fires have occurred most frequently when firing oil or shortly after changing to pulverized coal from oil.

**5-6.2.3** Temperature sensors should be provided in the inlet and outlet ducts for both flue gas and air. An alarm should be provided in the control room to alarm when air or flue gas temperatures exceed 50°F (28°C) above normal operating temperature. Temperature sensors alone may not be adequate to provide early warning of a fire in an air heater. In large air heaters, air flow rates are high enough so that a fire will be well developed before the temperature increases enough to alarm and warn the operator. The length of time the operator has to take action is greatly reduced, and severe damage can occur. The installation of a special detection system may allow operators time to quickly detect a fire, isolate the air heater, open drains, and activate the water spray system.

NOTE: Special detection systems currently used are:

- (a) Infrared detection systems to monitor rotor or stator surfaces, and
- (b) Line-type detectors between intermediate and cold-end basket layers

There has been limited fire experience with both systems to date. Low light television cameras mounted outside the air heater have a possible application in air heater fire detection.

**5-6.2.4** A minimum of one observation port should be provided in the inlet and/or outlet ducts for both flue gas and air. Large air heaters may require more than one observation port. Observation ports should be placed such that they are accessible for viewing the rotor or stator surface.

**5-6.2.5** A manual water spray system should be provided to protect the rotor or stator. The water spray system should be capable of being activated from the control room or from the air heater area or both. When the rotor or stator is horizontal, water spray applied to the upper surface can be expected to flow by gravity down over plate surfaces. A minimum of 0.60 gpm/ft<sup>2</sup> (0.41 L/sec-m<sup>2</sup>) density is recommended. When the rotor or stator is vertical, water spray must be applied to both sides to obtain adequate

penetration. A minimum of 0.30 gpm/ft<sup>2</sup> (0.20 L/sec-m<sup>2</sup>) density is recommended on both sides. Water wash systems may not be adequate to give full coverage because of rotor drive failure.

**5-6.2.6** Access hatches for use of hose streams should be provided. Hatches should be designed for quick access. A minimum of one hatch should be provided per 10 ft (3.0 m) of rotor or stator diameter. For horizontal shaft air heaters, access should be provided on both sides of the rotor or stator. For vertical shaft units, access hatches should be provided above the rotor or stator with one hatch below for units under 20 ft (6.1 m) diameter and two hatches below for units 20 ft (6.1 m) or more in diameter.

**5-6.2.7** Drains from air heaters or ducts or both should be accessible or controlled by remotely operated valves.

**5-6.2.8** A zero speed switch with alarm in the control room should be provided on the rotor shaft or on the output shaft from the fluid coupling or gear reducer. A zero speed alarm warns of stoppage of the rotor or air hoods. This could be due to failure of the drive motor or coupling that will lead to overheating of a section of the rotor or stator, which may result in a fire. Stoppage may also be caused by high temperatures generated by a fire that has caused the rotor to bind against the housing or the air hoods to bind against the stator.

### 5-6.3 Flue Gas Bag-Type Dust Collectors.

**5-6.3.1** Flue gas bag-type dust collectors (also known as fabric filters) can be damaged by overheating or fire. Filter media can be damaged by flue gases entering at a temperature above the operating temperature of the filter media. Fires have been caused by incomplete combustion in the boiler resulting in carryover of burning particulate igniting the filter media and by maintenance operations such as cutting and welding.

**5-6.3.2** Collectors equipped with bags that have an operating temperature limit exceeding 400°F (204°C) should be subdivided into compartments by noncombustible partitions. The partitions should extend through the flue gas bag area. The filter bag area provided in each compartment should be such that the fabric filter systems will not limit boiler load with one compartment fully isolated to repair damaged filter bags. The pressure drop across the fabric filter system should not increase significantly when one compartment is isolated.

**5-6.3.3** Collectors equipped with other types of bags should be subdivided into compartments by partitions of 30-minute fire resistance if no automatic sprinkler protection is provided or by noncombustible partitions if sprinklers are provided. Partitions should extend from the hopper, through the bag area to the clean air plenum. Protection inside dust collectors should include the bag area. The design density should be 0.20 gpm/sq ft (0.14 L/sec-m<sup>2</sup>) over the plan area of the dust collector.

**5-6.3.4** If automatic sprinkler protection is provided, structural design of the collector should take into consideration maximum water loading. A method should be provided for drainage of water from the hoppers.

**5-6.3.5** Each compartment should be equipped with a heat detection system, arranged to alarm in a constantly attended area at a temperature 50°F (28°C) above normal operating temperature.

**5-6.3.6** One of the following should be provided to prevent high temperature inlet flue gas from damaging the bags:

(a) Where permitted for emergency conditions, an automatic isolation valve and bypass duct to divert inlet gas streams around the flue gas bag collector, or

(b) A flue gas tempering water spray system in the duct between the boiler and the flue gas bag collector.

**5-6.3.7** Manual fire fighting equipment should be available to personnel performing maintenance on a collector. A standpipe system should be provided such that each compartment is accessible by at least one hose system.

**5-6.3.8** Access doors or hatches for manual fire fighting and viewing ports should be provided for all compartments.

### 5-6.4 Electrostatic Precipitators.

**5-6.4.1** Electrostatic precipitators can be damaged by heat from a fire. High temperatures can warp collecting plates, decreasing collection efficiency. Combustibles may be generated by over-rich boiler-turbine firing. Solid and liquid products of incomplete combustion can be collected on plate surfaces. Ignition can occur by arcing in the electrostatic precipitator.

**5-6.4.2** Temperature sensors should be provided in the inlet and outlet ducts. Alarms should be provided in the control room to indicate abnormal operating temperatures.

NOTE: Temperature sensors alone may not be adequate to provide early warning of a fire in an electrostatic precipitator.

**5-6.4.3** Transformer-rectifier sets should use high fire point insulating fluids or should be of the dry type. If mineral oil insulating fluids are used, hydrants or standpipes should be located so that each transformer-rectifier set can be reached by at least one hose stream. In addition either of the following should be provided:

(a) Automatic sprinkler or automatic water spray protection. Fire protection water spray systems provided for transformer-rectifier sets should be designed for a density of 0.25 gpm/ft<sup>2</sup> (0.17 L/sec-m<sup>2</sup>) over the exposed surface of the transformer-rectifier set. Automatic sprinkler systems should be designed for a density of 0.25 gpm/sq ft (0.17 L/sec-m<sup>2</sup>) over 3500 sq ft (325 m<sup>2</sup>). The drain system should be capable of handling oil spillage plus the largest design water flow from the fire protection system.

(b) Fire barrier(s) or spatial separation in accordance with Chapter 3. (See 3-1.3 and 3-1.4.)

### 5-6.5 Scrubbers and Exhaust Ducts.

**5-6.5.1 General.** Fires can occur in scrubbers with combustible packing or linings. Fire can also occur in ducts with plastic or rubber linings.



**5-6.5.2 Materials of Construction.** Scrubbers, internal piping, and ducts should be constructed of noncombustible materials if possible.

**5-6.5.3 Construction/Outage.** Experience indicates that fires have occurred during construction or maintenance outages. Cutting, welding, or other hot work is a likely ignition source, and strict administrative controls should be enforced. All combustible lined equipment should be identified with warning signs or placards. Consideration should be given to closing the absorber outlet damper during cutting, welding, or other hot work to reduce the induced draft.

#### **5-6.5.4 Fire Protection.**

**5-6.5.4.1** Due to the unique design and operating features of scrubbers, designers should consult with the scrubber manufacturer for guidance as to the materials suitable for internal use and specific protection design features.

**5-6.5.4.2** Where combustible packing or linings are used, the scrubber or ducts should be protected with water spray systems. These systems may be the spray systems designed for normal scrubber operation or a specially designed fire protection system. Where scrubber spray systems are used for fire protection, system components within the scrubber should be of noncombustible construction. The water supply should be from a source that is reliable and available during an outage.

**5-6.5.4.3** Specially designed fire protection water spray systems required for scrubbers or ducts with combustible packing or linings should be designed such that spray patterns are not obstructed and that they cover the packing or linings completely. The design criteria will be dependent on the specific material used, its ease of ignition, flame spread, rate of heat release, etc.

**5-6.5.4.4** Corrosion-resistant and noncombustible materials should be used for the fixed water spray system. Corrosion resistant blow-off caps on the spray nozzles used for specially designed fire protection systems should be provided to prevent nozzle plugging.

**5-6.5.5 Limestone Conveyors.** Limestone conveyors for use with flue gas desulfurization systems should meet the fire protection recommendations of 5-4.4.1, 5-4.4.2, 5-4.4.3, and 5-4.5.1.

#### **5-6.6 Stacks.**

**5-6.6.1** Noncombustible liners should be used where practical. (See Appendix B for fire tests.)

**5-6.6.2** Combustibles should not be stored in the space between the concrete shell and the combustible liner unless the liner is adequately protected by a fire barrier. The barrier could be either a 2-hr fire barrier or a 1-hr fire barrier if automatic sprinkler protection is provided over the combustible material.

**5-6.6.3** A fire protection system should be provided for maintenance operations inside plastic stack liners. A fixed protection system installed on scaffolding is recommended.

It should be capable of both manual and automatic operation and designed to protect the work platform and twice the area that can be reached by workers on the platform.

**5-6.6.4** Ignition sources should be eliminated when working inside plastic liners.

#### **5-7 Turbine-Generator.**

##### **5-7.1 Hydrogen System.**

###### **5-7.1.1 General.**

**5-7.1.1.1** For hydrogen storage systems see NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, or NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites*.

**5-7.1.1.2** Bulk hydrogen systems supplying one or more generators should have automatic valves located at the supply and operable either by "dead man" type controls at the generator fill point(s) or operable from the control room. This would minimize the potential for a major discharge of hydrogen in the event of a leak from piping inside the plant. Alternatively, vented guard piping may be used in the building to protect runs of hydrogen piping.

**5-7.1.1.3** Routing of hydrogen piping should avoid hazardous areas and areas containing critical equipment.

###### **5-7.1.2 Hydrogen Seal Oil Pumps.**

**5-7.1.2.1** Redundant hydrogen seal oil pumps with separate power supplies should be provided for adequate reliability of seal oil supply.

**5-7.1.2.2** Where feasible, electrical circuits to redundant pumps should be run in buried conduit or provided with fire retardant coating if exposed in the area of the turbine generator to minimize possibility of loss of both pumps as a result of a turbine generator fire.

**5-7.1.3** Curbing or drainage or both should be provided for the hydrogen seal oil unit in accordance with Section 3-5.

**5-7.1.4** A flanged spool piece or equivalent arrangement should be provided to facilitate the separation of hydrogen supply when the generator is opened for maintenance.

**5-7.1.5** For electrical equipment in the vicinity of the hydrogen handling equipment, including detrainning equipment, seal oil pumps, valves, etc., see Article 500 of NFPA 70, *National Electrical Code*, and Section 127 of ANSI C2, *National Electrical Safety Code*.

**5-7.1.6** Control room alarms should be provided to indicate abnormal gas pressure, temperature, and percentage of hydrogen in the generator.

**5-7.1.7** Hydrogen lines should not be piped into the control room.

**5-7.1.8** The generator hydrogen dump valve and hydrogen detrainning equipment should be arranged to vent directly to a safe outside location. The dump valve should

be remotely operable from the control room or an area accessible during a machine fire.

### 5-7.2 Hydraulic Control System.

**5-7.2.1** The hydraulic control system should use a listed fire resistant fluid.

**5-7.2.2** If a listed fire resistant fluid is not used, hydraulic control equipment should be protected as described in 5-7.4.

**5-7.2.3** Fire extinguishing systems, where required for hydraulic control equipment, should include reservoirs and stop, intercept, and reheat valves.

### 5-7.3 Lubricating Oil Systems.

**5-7.3.1** Turbine lubricating oil reservoirs should be provided with a vapor extractor, vented to a safe outside location.

**5-7.3.2** Curbing or drainage or both should be provided for the turbine lubricating oil reservoir in accordance with Section 3-5.

**5-7.3.3** All oil piping serving the turbine-generator should be designed and installed to minimize the possibility of an oil fire in the event of severe turbine vibration.

**5-7.3.4** Piping design and installation should consider the following protective measures:

- (a) Welded construction.
- (b) Guard pipe construction with the pressure feed line located inside the return line or in a separate shield pipe drained to the oil reservoir.
- (c) Route oil piping clear of or below steam piping or metal parts.
- (d) Insulation with impervious lagging for steam piping or hot metal parts under or near oil piping or turbine bearing points.

NOTE: On some turbine-generators employing the guard pipe principle, the guard piping arrangement terminates under the machine housing where feed and return piping run to pairs of bearings. Such locations are vulnerable to breakage with attendant release of oil in the event of excessive machine vibration and should be protected.

**5-7.3.5** It is desirable to provide for remote operation, preferably from the control room, of the condenser vacuum break valve and the lubricating oil pumps. Breaking the condenser vacuum markedly reduces the rundown time for the machine and thus limits oil discharge in the event of a leak. See discussion in 2-7.2 on fire emergency planning involving turbine lubricating oil fires.

**5-7.3.6** Cable for operation of lube oil pumps should be protected from fire exposure. Protection may consist of separation of cable for AC and DC oil pumps or 1-hr fire resistive coating (derating of cable should be considered).

### 5-7.4 Fire Protection.

#### 5-7.4.1 Beneath Turbine-Generator Operating Floor.

**5-7.4.1.1** All areas beneath the turbine-generator operating floor that are subject to oil flow, oil spray, or accumulation should be protected by an automatic sprinkler or

foam-water sprinkler system. This coverage normally includes all areas beneath the operating floor in the turbine building. The sprinkler system beneath the turbine-generator should take into consideration obstructions from structural members and piping and should be designed to a density of 0.30 gpm per sq ft (0.20 L/sec-m<sup>2</sup>) over a minimum application of 5000 sq ft (464 m<sup>2</sup>).

NOTE: To avoid water application to hot parts or other water sensitive areas and to provide adequate coverage, designs that incorporate items such as fusible element operated directional spray nozzles may be necessary.

**5-7.4.1.2** Foam-water sprinkler systems installed in place of automatic sprinklers described above should be designed in accordance with NFPA 16 or NFPA 16A and the design densities specified above.

**5-7.4.1.3** Electrical equipment in the area covered by a water or foam-water system should be of the enclosed type or otherwise protected to minimize water damage in the event of system operation.

#### 5-7.4.2 Turbine-Generator Bearings.

NOTE: Additional information concerning turbine-generator fire protection can be found in EPRI Research Project 1843-2 report, *Turbine Generator Fire Protection by Sprinkler System*, July 1985.

**5-7.4.2.1** Turbine-generator bearings should be protected with a manually or automatically operated closed-head sprinkler system utilizing directional nozzles. Fire protection systems for turbine-generator bearings should be designed for a density of 0.25 gpm per sq ft (0.17 L/sec-m<sup>2</sup>) over the protected area.

**5-7.4.2.2** Accidental water discharge on bearing points and hot turbine parts should be considered. If necessary, these areas may be protected by shields and encasing insulation with metal covers.

**5-7.4.2.3** If a manually operated water system is installed, consideration should be given to a supplemental automatic gaseous fire extinguishing system.

**5-7.4.3** Lubricating oil lines above the turbine operating floor should be protected with an automatic sprinkler system covering those areas subject to oil accumulation including the area within the turbine lagging (skirt). The automatic sprinkler system should be designed to a density of 0.30 gpm per sq ft (0.20 L/sec-m<sup>2</sup>).

**5-7.4.4** Lubricating oil reservoirs and handling equipment should be protected in accordance with 5-7.4.1. If the lubricating oil equipment is in a separate room enclosure, protection may be provided by a total flooding gaseous extinguishing system.

NOTE: If the lubricating oil reservoir is elevated, sprinkler protection should be extended to protect the area beneath the reservoir.

**5-7.4.5** The area inside a directly connected exciter housing should be protected with a total flooding automatic carbon dioxide system.

**5-7.4.6** Hydrogen seal oil units should be protected in accordance with 5-7.4.1.

**5-7.4.7** Clean/dirty oil storage areas should be protected based on the fire risk evaluation. This area generally represents the largest concentrated oil storage in the plant. The designer should consider, as a minimum, the installation of fixed automatic fire protection systems and the ventilation and drainage requirements in Chapter 3.

## **5-8 Electrical Equipment.**

### **5-8.1 Control, Computer, and Communication Rooms.**

**5-8.1.1** Control/computer/telecommunication rooms should meet applicable requirements of NFPA 75, *Standard for the Protection of Electronic Computer Data Processing Equipment*.

**5-8.1.2** A smoke detection system should be installed throughout these rooms, including walk-in-type consoles, above suspended ceilings where combustibles are installed, and below raised floors. Where the only combustibles above the false ceiling are cables in conduit and the space is not used as a return air plenum, smoke detectors may be omitted from this area.

**5-8.1.3** A preaction sprinkler system for the computer or telecommunications rooms should be considered during the fire risk evaluation. In addition, Halon 1301 fire extinguishing systems or carbon dioxide fire extinguishing systems should be considered for areas beneath raised floors that contain cables or for areas or enclosures containing equipment that is of high value or is critical to power generation. Individual equipment cabinet protection could be considered in lieu of total flooding systems.

**5-8.1.4** Cable raceways not terminating in the control room should not be routed through the control room.

### **5-8.2 Cable Spreading Room and Cable Tunnels.**

**5-8.2.1** Cable spreading rooms and cable tunnels should be protected with automatic sprinkler, water spray, or automatic gaseous extinguishing systems. Automatic sprinkler systems should be designed for a density of 0.30 gpm/sq ft (0.20 L/sec-m<sup>2</sup>) over 2500 sq ft (232 m<sup>2</sup>) or the most remote 100 linear ft (30 m) of cable tunnels up to 2500 sq ft (232 m<sup>2</sup>). For Halon 1301 systems a design concentration of 6 percent for a 10 minute soaking time should be provided.

**5-8.2.2** Cable spreading rooms and cable tunnels should be provided with an early warning fire detection system.

### **5-8.3 Grouped Electrical Cables.**

**5-8.3.1** Consideration should be given to the use of fire retardant cable insulation such as those passing the Flame Propagation Test of the Institute of Electrical and Electronics Engineers (IEEE-383). Grouped electrical cables should be routed away from exposure hazards or protected as required by the fire risk evaluation. In particular, care should be taken to avoid routing cable trays near

sources of ignition or flammable/combustible liquids. Where such routing is unavoidable, cable trays should be designed and arranged to prevent the spread of fire.

**5-8.3.2** Cable trays subject to accumulation of coal dust and the spread of an oil spill should be covered by sheet metal. Where potential oil leakage is a problem, solid-bottom trays should be avoided. Changes in elevation can prevent oil travel along cables in a tray.

**5-8.3.3** The fire risk evaluation should consider the provision of fire suppression systems or fire retardant cable coatings or both for protection of cable concentrations from exposure fires. Care should be exercised in the selection of fire retardant coatings to ensure that derating of the cable is considered. Consideration also should be given to the ability to add or remove cables and to make repairs to cables protected with fire retardant coatings.

**5-8.4 Switchgear and Relay Rooms.** Switchgear rooms and relay rooms should be provided with smoke detection systems.

**5-8.5 Battery Rooms.** Battery rooms should be provided with ventilation to limit the concentration of hydrogen to 1 percent by volume. For further information refer to ANSI IEEE 484, *Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations*.

**5-8.6 Transformers.** Oil-filled main, station service, and start-up transformers should be protected with automatic water spray or foam-water spray systems.

**5-8.7 Substations and Switchyards.** Substations and switchyards located at the generating facility, utilizing combustible oil filled equipment should be protected by the yard fire hydrant system where practical. Spatial separation of transformers and other equipment containing over 500 gal of oil should be in accordance with 3-1.3. Consideration should be given to water spray protection of transformers critical to the transmission of the generated power.

NOTE: For information pertaining to fire protection guidelines for substations, see ANSI IEEE 979, *Guide for Substation Fire Protection*.

## **5-9 Auxiliary Equipment and Other Structures.**

### **5-9.1 Emergency Generators.**

**5-9.1.1** The installation and operation of emergency generators should be in accordance with NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*.

### **5-9.1.2 Fire Protection.**

**5-9.1.2.1** Emergency generators located within main plant structures should be protected by automatic sprinkler, water spray, foam-water sprinkler, or gaseous-type extinguishing systems. Sprinkler and water spray protection systems should be designed for a 0.25 gpm/ft<sup>2</sup> (0.17 L/sec-m<sup>2</sup>) density over the fire area.

**5-9.1.2.2** Where gaseous suppression systems are used on combustion engines that may be required to operate during the system discharges, consideration should be given to the supply of engine combustion air and outside air for equipment cooling.

**5-9.2 Storage Rooms, Offices, and Shops.** Automatic sprinklers should be provided for storage rooms, offices, and shops containing combustible materials that present an exposure to surrounding areas that are critical to plant operations. (For oil storage rooms, see 5-7.4.7.)

**5-9.3 Warehouses.** Automatic sprinklers should be provided for warehouses that contain high-value equipment and combustible materials that are critical to power generation or that constitute a fire exposure to other important buildings.

**5-9.4 Fire Pumps.** Rooms housing diesel-driven fire pumps should be protected by automatic sprinkler, water spray, or foam-water sprinkler systems. If sprinkler and water spray protection systems are provided for fire pump houses, they should be designed for a density of 0.25 gpm/sq ft (0.17 L/sec-m<sup>2</sup>) over the fire area.

**5-9.5 Cooling Towers.** Cooling towers of combustible construction that are essential to continued plant operations should be protected by automatic sprinkler or water spray systems in accordance with NFPA 214, *Standard on Water-Cooling Towers*.

#### 5-9.6 Auxiliary Boilers.

**5-9.6.1** Auxiliary boiler-furnaces, their fuel burning systems, combustion products removal systems, and related control equipment should be designed, installed, and operated in accordance with Section 5-5.

**5-9.6.2** Oil- or coal-fueled auxiliary boilers installed within main plant structures should be protected by automatic sprinkler, water spray, or foam-water sprinkler systems. A sprinkler system is preferred throughout the auxiliary boiler room on a 0.25 gpm/sq ft (0.17 L/sec-m<sup>2</sup>) density. As a minimum, sprinkler or water spray protection should be provided as outlined in 5-5.1.

**5-9.7** Vehicle repair facilities should meet the requirements of NFPA 88B, *Standard for Repair Garages*.

## Chapter 6 Identification and Protection of Hazards for Combustion Turbines

### 6-1 General.

**6-1.1** This chapter identifies fire and explosion hazards of combustion turbine electric generating units and specifies recommended protection criteria.

**6-1.2** It should be recognized that some combustion turbine generating facilities consist of manufactured modules wherein construction consists of siting these modules, providing fuel supply, essential services, and interconnections to the electric system, while other facilities consist of build-

ings specifically designed and built or modified for the combustion turbine generator and its auxiliaries. Therefore, some of these recommendations may be more applicable to one type of plant than the other.

### 6-2 Application of Chapters 2 through 5 and Chapter 8.

The recommendations contained in Chapters 2 through 5 and Chapter 8 may apply to combustion turbine electric generating units. It is incumbent on the fire risk evaluation to determine which recommendations apply to any specific combustion turbine unit. This is done by evaluating the specific hazards that exist in the facility and evaluating the level of acceptable risk for the facility. For large combustion turbine units or combined cycle plants, it is expected that most of the recommendations will apply, whereas for individual packaged combustion turbine units, many of the recommendations will not apply since the hazards described may not exist (e.g., small units may have no cable spreading room or warehouse).

### 6-3 General Design and Equipment Arrangement.

**6-3.1** Adequate separation should be provided, as determined by the fire risk evaluation, between:

- (a) Adjacent combustion turbine units
- (b) Adjacent structures or exposures.
- (c) Adjacent properties (e.g., tank farms or natural gas facilities that could present a severe exposure).

**6-3.2** Consideration should be given to equipment layout that is adjacent to combustion turbines and in line with planes of turbine and compressor disks that have a higher potential for damage from flying debris.

**6-4 Unattended Facilities.** Facilities that are operated unattended present special fire protection concerns.

**6-4.1** Consideration should be given both to the delayed response time of the fire brigade or public fire fighting personnel (which may be several hours) and to the lack of personnel available to alert others to a fire condition.

**6-4.2** The fire risk evaluation should address delayed response and lack of communication. This may establish the need to provide additional fire protection measures to prevent a major fire spread prior to the arrival of fire fighting personnel. The delayed response by personnel to the site may necessitate automatic shutoff of fire pumps.

**6-4.3** If automatic water or foam fire suppression systems are utilized, a cycling deluge valve should be considered. The arrangement will depend on the type of system and the hazard protected. Thermal detection is recommended.

**6-4.4** Remote annunciation of the fire signaling panel to one or more constantly attended locations is critical for emergency response. The fire signaling panel should be located at the entry to the unattended plant.

**6-4.5** It is important that the responding fire brigade or public fire fighting forces be familiar with access, plant fire protection systems, emergency lighting, specific hazards, and methods of fire control. This should be reflected in the plant fire emergency plan (see Section 2-7).

**6-4.6** If an automatic foam system is provided for the fuel storage tanks, a cycling system could be provided to shut down the system when the foam concentrate supply is exhausted.

## **6-5 Combustion Turbine Generators.**

### **6-5.1 General.**

**6-5.1.1** Site-specific design conditions or manufacturers' typical design will govern which equipment has enclosures or how many separate enclosures will be provided for the combustion turbine generator equipment. The combustion turbine generator is frequently supplied as a complete power plant package with equipment mounted on skids or pads and provided with metal enclosures forming an all-weather housing. In addition to being weather tight, the enclosures are designed to provide thermal and acoustical insulation.

**6-5.1.2** The major fire hazards associated with combustion turbine generator units are:

- (a) Flammable and combustible fuels, and
- (b) Hydraulic and lubricating oils.

**6-5.1.3** In the event of a pipe failure, large amounts of oil or fuel could be released and ignite on contact with hot metal parts. In addition to external fire hazards, combustion turbines are subject to the hazard of uncontrolled internal fires if flameout occurs and the fuel is not shut off immediately, or if fuel is admitted to a hot engine and ignition does not occur. Other hazards associated with the combustion turbine generators are:

- (a) Electrical equipment, and
- (b) Large amounts of filter media and enclosure insulation.

### **6-5.2 Prevention of Internal Fires in Combustion Turbines.**

**6-5.2.1** Combustion turbines should have flame detectors in the combustion section to detect flameout or ignition failure during startup. In the case of flameout the fuel should be rapidly shut off. If ignition is not achieved within a normal startup time, then the control system should abort the startup and close the fuel valves.

**NOTE:** When a flameout occurs, fuel valves should close as rapidly as possible (preferably less than 1 second) to preclude the accumulation of unburned fuel in the combustion chamber. Loss experience documents that fires or explosions have occurred in systems when the fuel isolation was not achieved within 3 seconds.

**6-5.2.2** In order to prevent conditions that could cause a fire while the unit is operating, control packages for combustion turbines should include the following monitors:

- (a) Turbine speed sensor, independent of the main governor, for tripping on overspeed.
- (b) Vibration monitors at the main turbine bearings, for tripping on excessive vibration.

(c) Turbine exhaust temperature monitor, for tripping on high temperature.

**NOTE:** Monitors for conditions (b) and (c) should have a lower alarm point to alert operators of deteriorating operating conditions. See ANSI B133.4, *Gas Turbine Control and Protection Systems*.

**6-5.2.3** Two safety shutoff valves in series on the main fuel line should be used to minimize the likelihood of fuel leaking into the engine. On gas systems an automatic vent to the outside atmosphere should be provided between the two valves.

### **6-5.3 Prevention of External Fires in Combustion Turbines.**

**6-5.3.1** Piping systems supplying flammable and combustible liquids and gases should be designed to minimize oil and fuel piping failures as described below.

(a) If rigid metal piping is used, it should be designed with freedom to deflect with the engine, in any direction, at the interface with the turbine. This recommendation also should apply to hydraulic lines that are connected to accessory gearboxes or actuators mounted directly in the engine. Properly designed metallic hose is an alternative for fuel, hydraulic, and lube oil lines in high vibration areas, between rigid pipe supply lines and manifolds, and the points of entry at the engine interface.

(b) Rigid piping connected directly to the turbine should be supported such that failures will not occur due to the natural frequency of the piping coinciding with the rotational speed of the combustion turbine. Care should be taken in the design of pipe supports to avoid vibrations induced by other equipment that may excite its natural frequency.

(c) Welded pipe joints should be used where practical. Threaded couplings and flange bolts in fuel and oil piping should be assembled using a torque wrench and torqued to the manufacturer's requirements. Couplings should have a positive locking device to prevent unscrewing.

(d) Instrumentation tubing, piping, and gauges should be protected from accidental mechanical damage. Sight glasses should be unbreakable.

(e) Where practical, lubricating oil lines should use pipe guard construction with the pressure feed line located inside the return line.

**6-5.3.2** In many units the lubricating oil is used for both lubrication and hydraulic control. A listed fire resistive fluid should be considered for use in both systems. If separate systems are used, the hydraulic control system should use a listed fire resistive hydraulic fluid.

**6-5.3.3** Combustible gas detector(s) should be considered for the enclosure when the fuel for the gas turbine is natural gas or other gaseous-type fuels.

**6-5.3.4** For recommendations regarding containment and drainage of liquids, see Section 3-5.

### **6-5.4 Fire Protection for Combustion Turbine.**

**6-5.4.1** Determination of the need for fire suppression for the combustion turbine should be based on consideration of the following: size and value of the combustion turbine, consequences of loss of the combustion turbine, and vulnerability of adjacent structures and equipment to damage

**6-5.4.2** Water suppression systems, where provided, should follow the recommendations in Chapter 5 and the following criteria:

(a) Water spray nozzles provided to protect the power turbine bearing housings behind the exhaust duct should be directed based on unit geometry to avoid possible water damage.

(b) Automatic sprinkler or water spray protection should be provided for exposed oil piping and areas on the floor under the turbine where leaking oil may collect.

(c) Water spray nozzles should not be directed at the turbine casing or the combustor.

(d) Fuel valves should be arranged to close automatically on water flow.

#### **6-5.4.3 Total Flooding Gaseous Systems.**

**6-5.4.3.1** Where total flooding gaseous systems are used, the turbine enclosure should be arranged for minimum leakage by automatic closing of the doors, ventilation dampers, and automatic shutdown of the fans and other openings. Combustion turbine compartments are designed to be capable of nominally air-tight closure. During operation there is, however, a need for substantial amounts of secondary cooling (compartment ventilation) air. This air can be moved through the compartments by fans or venturi action from the turbine combustion air. This air flow will not stop immediately upon shutdown, and, therefore, it must be considered in the extinguishing system design.

**6-5.4.3.2** Gas design concentrations should be held as long as the hazards of hot metal surfaces above the auto-ignition temperature and uncontrolled combustible liquid flow exist (consult manufacturer for cool down times). Proper gaseous extinguishing system design dictates that the design concentration be held in the compartment for the cooling time discussed above to take place. This has been shown to be around 20 minutes for many areas, but can be substantially longer. It also has been shown that the initial gas discharge will not hold for a 20-min time period in most turbine compartments. Therefore, the designer must determine the level of an extended added discharge that is necessary to maintain fire extinguishment. This usually requires discharge testing to determine if design concentrations can be maintained. Where gas concentrations cannot be effectively maintained, an alternative system, such as high-expansion foam or water extinguishing system, may be desirable.

**6-5.4.3.3** System operations should be arranged to close the fuel valves.

**6-5.4.3.4** Maintenance of total flooding systems is particularly critical. In addition to the extinguishing equipment, the integrity of the enclosure to be flooded and the interlocks between the two should be maintained.

**6-5.4.3.5** It should be noted that deep seated fires, such as oil-soaked insulation, may be present and will require manual extinguishment after the gaseous system soak time.

**6-5.4.3.6** For combustion turbines located indoors, provisions should be addressed for safely removing the gas and potential toxic combustion by-products from the turbine enclosure following system actuation.

**6-5.4.4 High-Expansion Foam Systems.** Where total flooding high-expansion foam systems are used for the enclosure in which the turbine is located, system operation should be arranged to close the fuel valves.

**6-5.4.5** Lubricating oil reservoirs and handling equipment should be protected in accordance with 5-7.3.1 and 5-7.4.4.

#### **6-5.5 Inlet Air Filter.**

**6-5.5.1** Air filters should be of a type that will not burn freely when exposed to fire. Filters qualifying as Class 1 as tested in accordance with UL 900, *Standard for Safety Test Performance of Air Filters*, meet these requirements.

**6-5.5.2** Manual fire fighting equipment should be available to personnel performing maintenance on air filters.

**6-5.5.3** Access doors or hatches should be provided for manual fire fighting on large air filter structures.

#### **6-5.6 Generator.**

**6-5.6.1** Hydrogen systems should comply with recommendations in 5-7.1 and 5-7.4.6.

**6-5.6.2** Fire protection should be provided in accordance with 6-5.4.1, 6-5.4.2, 6-5.4.3, or 6-5.4.4.

**6-5.6.3** Air-cooled generators should be tightly sealed against the ingress of moisture in the event of discharge (accidental or otherwise) of a water spray system. Sealing must be positive, such as by a gasket or grouting, all around the generator housing.

**6-5.7 Starting Equipment.** Fire protection should be provided for the starting equipment and its enclosure, based on consideration of the factors in 6-5.4.1.

#### **6-6 Electrical Equipment.**

**6-6.1 Control Enclosures.** The size of the combustion turbine generator and the site design determine whether control enclosures are provided. Control enclosures normally are used in remote locations and are designed to be unattended. Control enclosures contain turbine and generator control panels, switchgear, batteries, relays, and indication gauges.

**6-6.2 Auxiliary Electrical Equipment Enclosures.** Auxiliary electrical equipment enclosures, where provided, normally contain static excitation equipment, switchgear, current transformers, potential transformers, grounding transformers, and other electrical equipment.

**6-6.3** A smoke detection system should be provided for alarm only and early warning of an electrical fire.

**6-6.4** A total flooding gaseous suppression system should be considered for the enclosures.

#### **6-7 Combined Cycle Units.**

**6-7.1 Heat Recovery Steam Generators.** Heat recovery steam generators using supplemental firing should be designed and protected in accordance with Section 5-5.

**6-7.2 Steam Turbines.** Steam turbines, generators, and their associated hazards should be designed and protected in accordance with Section 5-7.

## Chapter 7 Alternative Fuels

**7-1 General.** This chapter identifies fire and explosion hazards of alternative fuel (e.g., RDF, MSW, biomass) fired electric generating plants and specifies recommended protection criteria.

**7-2 Application of Chapters 2 through 5 and Chapter 8.** The recommendations contained in Chapters 2 through 5 and Chapter 8 may apply to alternative fuel fired electric generating station units. It is incumbent upon the fire risk evaluation to determine which recommendations apply to any specific alternative fuel fired unit. This is done by evaluating the specific hazards that exist in the facility and determining the level of acceptable risk for the facility. It is expected that most of the recommendations will apply to all units, except where:

(a) Size and specific design eliminate certain hazards (e.g.,  $H_2$  seal oil units, cable spreading rooms, or warehouses), and

(b) The fire risk evaluation indicates a single source of water (e.g., a single tank) is considered adequate and reliable.

### 7-3 Mass Burn Fuels.

#### 7-3.1 General.

**7-3.1.1** This section (Section 7-3) identifies fire and explosion hazards that are unique to the use of municipal solid waste (MSW) as a boiler fuel by means of a process that includes the hauling of MSW directly to a tipping floor or storage pit and burning without any special processing. MSW is municipal solid waste consisting of commonly occurring residential and light commercial waste.

**7-3.1.2** The major fire and explosion hazards associated with mass burn units are:

(a) Sourcing, receipt, handling, and storage of large quantities of MSW.

(b) Unsuitable waste entering the facility: Examples include certain hydrocarbons, flammable liquids, metal dusts, acetylene, explosives, etc.

(c) Hydraulic and lubricating oils associated with the processing equipment.

(d) Improperly maintained electrical equipment.

(e) Large amounts of MSW accumulating in unsuitable areas as a result of spillage or handling.

(f) Inadequate dust control.

#### 7-3.2 Plant Arrangement.

**7-3.2.1** A MSW hot-load unloading area should be designated and separated from other areas (preferably outdoors) so that loads containing smoldering or other suspect

constituents can be segregated. Such areas should be properly monitored and equipped to promptly extinguish incipient fires before recombining with other MSW.

**7-3.2.2** The refuse pit is normally enclosed on three sides, up to the charging level, by reinforced concrete walls. The thickness of the walls vary with facility design, but should provide a minimum of 2-hr fire separation.

**7-3.2.3** Exposed steel columns located at the front of the refuse pit should be protected against structural damage caused by heat (fire). This protection could include concrete encasement, water spray, or other suitable alternatives and should extend from the base of the column to the roof of the refuse pit enclosure. Care should be taken to protect fire-proofing from mechanical damage.

**7-3.2.4** Smoke or heat vents should be considered in accordance with 3-4.1.

**7-3.2.5** Overhead cranes are often used to mix and stock the refuse within the pit. Undesirable waste (large items such as refrigerators) is often separated from the waste stock by the crane operator for offsite disposal or for shredding/processing (*see 7-5.5*) prior to replacement into the waste stock. All other items are loaded directly into boiler feed hoppers without processing. In addition, the acceptable method for extinguishment of small fires is also direct loading of the smoldering refuse into the hoppers by the crane operator. The following considerations should be given with respect to the crane operator's pulpit:

(a) Locating the pulpit such that operator safety is not compromised.

(b) Ability to have a clear and unobstructed view of all storage and charging areas.

(c) Providing self-contained breathing apparatus for operator egress.

(d) Providing direct communication with the boiler control room and floor manager.

(e) Ability to activate fire protection equipment.

**7-3.2.6** Boiler feed equipment, such as a chute or metering bin, should be of noncombustible material and designed to minimize pockets or corners that could cause combustible material to build up. Video monitoring should be considered for locations not readily visible to plant staff. For further guidance, see NFPA 8505, *Recommended Practice for Stoker Operation*.

**7-3.2.7** Mass burn facilities utilizing hammermills and flailmills should refer to the criteria in 7-4.2.3.

### 7-3.3 Prevention of Fires and Explosions in Mass Burn Units.

**7-3.3.1** A communication system should be provided between the floor manager and the control room to expedite assistance in the event of fire.

**7-3.3.2** The floor operators should ensure that MSW is continuously moved to the processing or storage areas. Vehicles loaded with MSW should not be parked in the building during idle periods.

**7-3.3.3** A regular program of housekeeping should be established to keep concentrations of combustible material to a minimum.

**7-3.3.4** Operational experience has demonstrated that roving operators and other plant personnel have been key factors in detection of fires and unsafe conditions. It is important that they be properly trained to observe and react to incipient fire situations. These should be reported to the control room operator for evaluation to determine what action is to be taken.

NOTE: The traffic pattern should minimize any requirement for storage of the MSW in tightly enclosed containers, such as trailers, to minimize the occurrence of spontaneous combustion of the fuel.

#### 7-3.4 Fire Protection.

**7-3.4.1** Hose stations designed in accordance with NFPA 14 should be located throughout MSW storage (tipping building), charging floor, firing floor, hydraulic area, and residue building. Due to the high frequency of use, the following points should be considered:

(a) Location and physical protection so as to avoid potential damage due to traffic patterns.

(b) Size and number to be determined for unique plant geometry (e.g., push walls).

(c) Ease of use, maintenance, and storage, such as through the use of continuous-flow, noncollapsible hose reels.

(d) Protection from freezing in unheated areas.

NOTE: Based on plant geometry, combustible loading, and staff size, a 250-gpm (946-L/min) monitor nozzle may be needed in lieu of or in conjunction with hoses.

**7-3.4.2** MSW conveyors should be protected in accordance with 5-4.6.2.

NOTE: Conveyors can be considered protected by overhead building protection if not enclosed or hooded.

**7-3.4.3** Hydraulic equipment, reservoirs, coolers, and associated oil filled equipment should be provided with automatic sprinkler or water spray protection. Sprinklers or spray nozzles should be over oil containing equipment and for 20 ft (6.1 m) beyond in all directions. A density of 0.25 gpm/ft<sup>2</sup> (10.19 L/min-m<sup>2</sup>) should be provided.

*Exception: Where a listed fire resistant fluid is used, protection is not needed.*

**7-3.4.4** The tipping receiving building should be provided with automatic sprinkler protection throughout. Systems should be designed for a minimum of 0.25 gpm/ft<sup>2</sup> (10.19 L/min-m<sup>2</sup>) over the most remote 3000 ft<sup>2</sup> (279 m<sup>2</sup>) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft<sup>2</sup> (120 m<sup>2</sup>). High temperature sprinklers [250°F (121°C) to 300°F (149°C)] should be used.

NOTE: The above requirements are based on storage heights not exceed 20 ft (6.1 m).

**7-3.4.5** The MSW storage pit, charging floor, and grapple laydown areas.

**7-3.4.5.1** Automatic sprinkler protection should be provided throughout the refuse enclosure to protect the entire roof area against structural damage. Systems should be designed for a minimum of 0.20 gpm/ft<sup>2</sup> (8.15 L/min-m<sup>2</sup>) over the most remote 3000 ft<sup>2</sup> (279 m<sup>2</sup>) (increase by 30 percent for dry pipe systems) of pit floor area with the protection area per sprinkler not to exceed 100 ft<sup>2</sup> (9.3 m<sup>2</sup>). High temperature sprinklers [250°F (121°C) to 300°F (149°C)] should be used. Exposed steel column protection, where provided, should be designed in accordance with NFPA 15 and can be connected to the overhead sprinkler system. Due to the distance between the bottom of the refuse pit and the sprinkler system, manual hoses and monitor nozzles should be considered as the primary means of fighting a MSW storage pit fire.

**7-3.4.5.2** In addition to sprinkler protection, the storage pit should be provided with monitor nozzle protection designed to furnish a minimum of 250 gpm (946 L/min) at 100 psi (689 Pa) at the tip. Monitors should be located so as to allow for coverage of all pit areas with at least two (2) streams operating simultaneously. Due to frequency of use and potential for operator fire exposure, oscillating monitor nozzles with manual override should be provided.

**7-3.4.6** Particular care should be taken in the selection of fire detection devices in consideration of harsh and dusty environments and high air flows.

**7-3.5 Explosion Suppression.** Mass burn facilities utilizing hammermills and flailmills for processing of oversize bulky waste should follow the recommendations of 7-4.2.3.

NOTE: Rotary shears utilizing manual or selective feeding demonstrate less of a hazard than hammermills and flailmills due to elimination of hazardous wastes by the operator during the feeding process.

#### 7-4 Refuse Derived Fuels (RDF).

##### 7-4.1 General.

**7-4.1.1** This section (Section 7-4) identifies fire and explosion hazards that are unique to the processing of municipal solid waste (MSW) into RDF. RDF is a boiler fuel manufactured by means of a process that includes storing, shredding, classifying, and conveying the waste to a fuel storage area. It is then conveyed to the boiler through a metering device.

**7-4.1.2** The major fire and explosion hazards associated with RDF fired units are:

(a) Sourcing, receipt, handling, and storage of large quantities of MSW.

(b) Unsuitable waste entering the processing stream. Examples include certain hydrocarbons, flammable liquids, metal dusts, acetylene, explosives, etc. In the event of unsuitable material entering the processing stream, severe explosion and fire could result in the shredders or flail mills.

(c) Handling and storage of large quantities of RDF.



(d) Hydraulic and lubricating oils associated with the processing equipment.

(e) Improperly maintained electrical equipment.

(f) Large amounts of MSW and RDF accumulating in unsuitable areas as a result of spillage, handling, or processing.

(g) Inadequate dust control.

#### 7-4.2 Plant Arrangement.

**7-4.2.1** Fire areas should be separated from each other by approved means. In addition to the applicable requirements of 3-1.1.2, it is recommended that, as a minimum, fire area boundaries be provided to separate:

(a) The tipping floor (including the MSW storage)

(b) The processing area

(c) RDF storage.

**7-4.2.2** Specific MSW and RDF hot-load unloading areas should be designated and separated from other areas (preferably outdoors) so that loads containing smoldering or other suspect constituents can be segregated. Such areas should be properly monitored and equipped to promptly extinguish incipient fires before recombining with other MSW and RDF.

**7-4.2.3** There is a potential fire and explosion hazard with the use of hammermills and flailmills and associated dust collection equipment. During the size-reduction process flammable or explosive materials in the waste stream may be ignited.

**7-4.2.3.1** The primary shredder and associated dust collectors should be located within an enclosure of damage-limiting construction. It is preferable that the enclosure be detached from the main building. Other alternatives included are locations:

(a) Outside of, but sharing a common wall with the main building

(b) Inside of the main building, along an outside wall

(c) Within the main building.

**CAUTION:** In view of the difficulties in preventing and controlling all types of shredder explosions, it is important to isolate the shredder and surrounding enclosure from vulnerable equipment and occupied areas in the plant. Consideration should be given to the protection of operating personnel or visitors from the potential blast zone.

**7-4.2.3.2** Secondary shredders do not exhibit as significant a fire and explosion potential as for primary shredders. Where specific designs do not eliminate the potential for explosions in the secondary shredder, refer to 7-4.2.3.1.

**7-4.2.3.3** Shredders, shredder enclosures, and openings into the enclosure should be designed so that, by a combination of venting and wall strength, they will resist a postulated worst credible case explosion. Consideration should be given to a substantial increase in explosive pressure as a result of venting of shredders into a combustible vapor-air mixture within the enclosure. It is recommended

that designers seek guidance from those having specialized experience in the analysis of such hazards, including specifying and constructing of explosion venting and shredder enclosures.

**NOTE:** An example of the postulated worst credible case explosion might be an acetylene tank. Explosions involving detonable material are beyond the scope of this document.

**7-4.2.3.4** Platforms at intermediate elevations should be of open grating to reduce obstructions to the effective vent area.

**7-4.2.3.5** Electrical equipment located inside the shredder enclosure should be rated for use in both hazardous vapor and dust atmospheres in accordance with Articles 500 and 501 of NFPA 70, *National Electrical Code*.

**7-4.2.3.6** Service panels or controls for the shredder should be located so as not to expose operating personnel to the blast zone.

**7-4.2.3.7** Explosion venting should be sized using the hydrogen nomographs as described in NFPA 68, *Guide for Venting of Deflagrations*. Where ducts are used to vent explosions to the outside, consideration should also be given to increased pressure caused by the length of the vent duct. If the vent area available is inadequate for sufficient explosion venting because of the height of the vent stack or other factors, an explosion suppression system in the shredder should be used to augment the venting arrangement. Refer to 7-1.5.

**7-4.2.3.8** Where access door assemblies are provided for primary shredder enclosure, they should be kept secured to prevent unauthorized access when the equipment is operating. The access door assemblies should have the same pressure rating as the enclosure.

#### 7-4.2.4 Boiler Feed Equipment.

**7-4.2.4.1** Boiler feed equipment, such as a metering bin, should be of noncombustible material and designed to minimize pockets or corners that could cause combustible material to build up. Video monitoring should be considered for locations not readily visible to plant staff. For further guidance, see NFPA 8505, *Recommended Practice for Stoker Operation*.

**7-4.2.4.2** Access hatches should be provided to allow operating personnel to break up accumulations of combustible material or plug gauges. In addition, the hatches should be placed so that the stream from a fire hose can be directed onto a fire that may occur inside the equipment.

**NOTE:** For personnel safety considerations, see NFPA 8505, *Recommended Practice for Stoker Operation*, for further guidance.

**7-4.2.5** Smoke or heat vents should be considered in accordance with 3-4.1.

#### 7-4.3 Prevention of Fires and Explosions in RDF Units.

**7-4.3.1** A communication system should be provided between the floor manager and the control room to expedite assistance in the event of fire.

**7-4.3.2** The floor operators should ensure that MSW is continuously moved to the processing or storage areas. Vehicles loaded with MSW or RDF should not be parked in the building during idle periods.

**7-4.3.3** A regular program of housekeeping should be established to keep concentrations of combustible material to a minimum.

**7-4.3.4** The process should be designed to minimize the production of dust. Dust collected in a dust collection system, baghouse, or cyclone should be discharged downstream of the collection system, back to the conveying system, or back to the residue or waste stream. For additional guidance, see 5-4.3.4.

**7-4.3.5** Operational experience has demonstrated that roving operators and other plant personnel have been key factors in detection of fires and unsafe conditions. It is important that they be properly trained to observe and react to incipient fire situations. These should be reported to the control room operator for evaluation to determine what action is to be taken.

NOTE: The traffic pattern should minimize any requirement for storage of the MSW or RDF in tightly enclosed containers, such as trailers, to minimize the occurrence of spontaneous combustion of the fuel.

#### 7-4.4 Fire Protection.

**7-4.4.1** Hose stations designed in accordance with NFPA 14 should be located throughout MSW storage (tipping building), processing structures, and RDF storage structures. Due to the high frequency of use, the following points should be considered:

(a) Location and physical protection so as to avoid potential damage due to traffic patterns.

(b) Size and number to be determined for unique plant geometry (e.g., push walls).

(c) Ease of use, maintenance, and storage, such as through the use of continuous-flow, noncollapsible hose reels.

(d) Protection from freezing in unheated areas.

NOTE: Based on plant geometry, combustible loading, and staff size, a 250-gpm (946 L/min) monitor nozzle may be needed in lieu of or in conjunction with hoses.

**7-4.4.2** Based on the combustible loading, location, and essential use, an automatic sprinkler system should be considered for dust collectors, baghouses, and cyclone type separators. See 5-4.6.5.

**7-4.4.3** MSW and RDF conveyors should be protected in accordance with 5-4.6.2.

NOTE: Experience has shown that shredder discharge conveyors are particularly susceptible to high fire frequencies. Consideration should be given to the use of water spray systems in conjunction with spark detection in these cases. Conveyors other than shredder discharge can be considered protected by overhead building protection, if not enclosed or hooded.

**7-4.4.3.1 Interlocks.** The actuation of a fire suppression system should cause equipment it protects to shut down. With the shutdown of the equipment, the upstream feed conveyors should also shut down to stop feeding combustible material to the fire, while downstream conveyors should be stopped to prevent the spread of the fire. A manual override should be provided.

NOTE: Where a facility has a rigidly enforced operating sequence and satisfies itself and the authority having jurisdiction that the operating practices and the judgment of the plant operators provide acceptable protection, this interlock with the fire protection system may be provided through operator action in accordance with operating procedures.

**7-4.4.4** Classifiers/trommels, such as rotating screens, should be provided with water spray protection to prevent fire from propagating downstream through the screen. Systems should be designed for a minimum of 0.25 gpm/ft<sup>2</sup> (10.19 L/min-m<sup>2</sup>) of the entire screen area with nozzles no more than 10 ft (3.0 m) on center. Consideration should be given to avoiding physical damage from mobile equipment operation in the area and from the material being processed.

**7-4.4.5** Hydraulic equipment, reservoirs, coolers, and associated oil filled equipment should be provided with automatic sprinkler or water spray protection. Sprinklers or spray nozzles should be over oil containing equipment and for 20 ft (6.1 m) beyond in all directions. A density of 0.25 gpm/ft<sup>2</sup> (10.19 L/min-m<sup>2</sup>) should be provided.

*Exception: Where a listed fire resistant fluid is used, protection is not needed.*

**7-4.4.6** The tipping/receiving building should be provided with automatic sprinkler protection throughout. Systems should be designed for a minimum of 0.25 gpm/ft<sup>2</sup> (10.19 L/min-m<sup>2</sup>) over the most remote 3000 ft<sup>2</sup> (279 m<sup>2</sup>) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft<sup>2</sup> (12.0 m<sup>2</sup>). High temperature sprinklers [250°F (121°C) to 300°F (149°C)] should be used.

NOTE: The above requirements are based on storage heights not exceeding 20 ft (6.1 m).

**7-4.4.7** The processing building should be provided with automatic sprinkler protection throughout. Systems should be designed for a minimum of 0.25 gpm/ft<sup>2</sup> (10.19 L/min-m<sup>2</sup>) over the most remote 3000 ft<sup>2</sup> (279 m<sup>2</sup>) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft<sup>2</sup> (12.0 m<sup>2</sup>).

NOTE: Due to the large quantity of platforms, equipment, and walkways, care should be taken to include coverage under all obstructions greater than 4 ft (1.2 m) wide.

**7-4.4.8** The RDF storage building should be provided with automatic sprinkler protection throughout. Systems should be designed for a minimum of 0.35 gpm/ft<sup>2</sup> (14.26 L/min-m<sup>2</sup>) over the most remote 3000 ft<sup>2</sup> (279 m<sup>2</sup>) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 100 ft<sup>2</sup> (9.3 m<sup>2</sup>). High temperature sprinklers [250°F (121°C) to 300°F (149°C)] should be used. Storage heights in excess of 20 ft (6.1 m) will require higher design densities.

**7-4.4.9** The RDF boiler feed system area, including bins, hoppers, chutes, conveyors, etc., should be considered for automatic sprinkler protection. Where provided, the systems should be designed for a minimum of 0.20 gpm-ft<sup>2</sup> (8.15 L/min-m<sup>2</sup>) over the most remote 2000 ft<sup>2</sup> (185.8 m<sup>2</sup>) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft<sup>2</sup> (12.0 m<sup>2</sup>). Internal, as well as external, protection should also be considered depending upon specific equipment design, ceiling heights, and accessibility for manual fire fighting.

**7-4.4.10** Shredder enclosures should be provided with automatic sprinkler or water spray protection. Systems should be designed for a minimum of 0.25 gpm-ft<sup>2</sup> (10.19 L/min-m<sup>2</sup>) over the most remote 3000 ft<sup>2</sup> (279 m<sup>2</sup>) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 100 ft<sup>2</sup> (9.3 m<sup>2</sup>). Water spray protection should also be provided within the shredder housings at intake and discharge chutes and within vent shafts.

**7-4.4.11** The environment should be considered in selecting detection devices. Heat detection is most reliable under conditions encountered in process areas. Smoke detection should not be used in process areas. If flame detectors are used, an air sweep of the lens should be provided.

#### 7-4.5 Explosion Suppression.

**7-4.5.1** Explosion suppression systems should be considered for protection of shredders. If such systems are selected, they should be designed and installed by qualified individuals using listed components. See NFPA 69, *Standard on Explosion Prevention Systems*, for further guidance.

**7-4.5.2** Explosion suppression system detectors and agent distribution should cover the entire shredder volume and all contiguous areas, including inlet and discharge conveyors, reject chutes, and dust collection systems.

**7-4.5.3** Mountings for explosion suppression system detectors and extinguishers must be cleaned frequently to ensure successful operation. Mountings, which include provisions for air purges, pneumatic rodding, and manual cleanout, have been found to be effective.

#### 7-5 Biomass Fuels.

##### 7-5.1 General.

**7-5.1.1** The section (Section 7-5) identifies fire and explosion hazards that are unique to the processing of forest and agricultural by-products (e.g., woodchips, rice hulls, sugar cane, etc.) into boiler fuel manufactured by means of a process that can include, but is not limited to, storing, shredding, classifying, and conveying the biomass to a fuel storage area and conveying it from the storage area to feed the boiler through a metering device. In general, biomass fuels are such that fires of low to moderate intensity would be expected. There can be cases, however, in which fuel type and processing will present a greater fire hazard and so require a higher level of protection.

**7-5.1.2** The major fire and explosion hazards associated with biomass fired units are:

(a) Sourcing, receipt, handling, and storage of large quantities of biomass.

(b) Unsuitable biomass (e.g., herbicides, explosives, flammable liquids, tramp metal) entering the processing stream.

(c) Hydraulic and lubricating oils associated with the processing equipment.

(d) Improperly maintained electrical equipment.

(e) Large amounts of biomass accumulating in unsuitable areas as a result of spillage, handling, or processing

(f) Inadequate dust control.

##### 7-5.2 Plant Arrangement.

**7-5.2.1** The initial biomass receiving and storage area, whether indoors or outdoors, should be designed in accordance with:

(a) NFPA 46, *Recommended Safe Practice for Storage of Forest Products*

(b) NFPA 61B, *Standard for the Prevention of Fires and Explosions in Grain Elevators and Facilities Handling Bulk Raw Agricultural Commodities*

(c) NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposure*

(d) NFPA 231, *Standard for General Storage*, Appendix C

(e) NFPA 299, *Standard for Protection of Life and Property from Wildfire*

(f) NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*.

**7-5.2.2** Specific biomass unloading areas should be designated and separated from other areas (preferably outdoors) so that loads containing smoldering or other suspect constituents can be segregated. Such areas should be properly staffed and equipped to promptly extinguish incipient fires before recombining with other biomass.

**7-5.2.3** Where process or handling equipment involves biomass materials with particle size less than 80 mesh and with moisture content less than 30 percent by volume, a potential explosion hazard exists. Refer to NFPA 68, *Guide for Venting of Deflagrations*; NFPA 69, *Standard on Explosion Prevention Systems*; and NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, for further guidance.

**7-5.2.4** Fire areas should be separated from each other by approved fire barriers, spatial separation, or other approved means. In addition to the requirements of 3-1.1.2, it is recommended that, as a minimum, fire area boundaries be provided to separate:

(a) The receiving/storage area

(b) The processing area.

**7-5.2.5** Boiler feed equipment, such as a metering bin, should be of noncombustible material and designed to minimize pockets or corners that could cause combustible material to build up. Video monitoring should be considered for locations not readily visible to plant staff. Refer to NFPA 8501, *Standard for Single Burner Boiler Operation*;

NFPA 85C, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boiler Furnaces*; NFPA 8503, *Standard for Pulverized Fuel Systems*; NFPA 8511, *Standard for the Prevention of Combustion Hazards in Atmospheric Fluidized Bed Combustion System Boilers*; and NFPA 8505, *Recommended Practice for Stoker Operation*.

**7-5.2.6** Where access hatches are provided, they should allow operating personnel to break up accumulations of combustible material or plug gauges. In addition, the hatches should be placed so that the stream from a fire hose can be directed onto a fire that may occur inside the equipment.

NOTE: For personnel safety considerations, see NFPA 8505, *Recommended Practice for Stoker Operation*, for further guidance.

**7-5.2.7** Smoke or heat vents should be considered in accordance with 3-4.1.

**7-5.2.8** For biomass facilities utilizing processes described in 7-5.2.4, refer to 7-3.2.3.

### **7-5.3 Prevention of Fires and Explosions in Biomass Units.**

**7-5.3.1 Outdoor Storage.** For the prevention of fires with outdoor storage of biomass, see NFPA 46, *Recommended Safe Practice for Storage of Forest Products*.

#### **7-5.3.2 Indoor Storage.**

**7-5.3.2.1** A communication system should be provided between facility personnel and the control room to expedite assistance in the event of fire.

**7-5.3.2.2** For biomass materials subject to spontaneous ignition, the piles should be rotated on a regular basis.

**7-5.3.2.3** Vehicles loaded with biomass should not be parked in the building or storage areas.

**7-5.3.2.4** A regular program of housekeeping should be established to keep concentrations of combustible material to a minimum.

**7-5.3.2.5** Operational experience has demonstrated that roving operators and other plant personnel have been key factors in detection of fires and unsafe conditions. It is important that they be properly trained to observe and react to incipient fire situations. These should be reported to the control room operator for evaluation to determine what action is to be taken.

**7-5.3.2.6** The process should be designed to minimize the production of dust. Dust collected in a dust collection system, baghouse, or cyclone should be discharged downstream of the collection system, back to the conveying system, or back to the residue or waste stream. For additional guidance, see 5-4.3.4.

### **7-5.4 Fire Protection.**

**7-5.4.1** For the fire protection of outdoor biomass material, see NFPA 46, *Recommended Safe Practice for Storage of Forest Products*.

**7-5.4.2** Hose stations designed in accordance with NFPA 14 should be located throughout the biomass storage, handling, and processing buildings. The following points should be considered:

(a) Location and physical protection so as to avoid potential damage due to traffic patterns.

(b) Size and number to be determined for unique plant geometry (e.g., push walls).

(c) Ease of use, maintenance, and storage, such as through the use of continuous-flow, noncollapsible hose reels.

(d) Protection from freezing in unheated areas.

NOTE: Based on plant geometry, combustible loading, and staff size, a 250-gpm (946 L min<sup>-1</sup>) monitor nozzle may be needed in lieu of or in conjunction with hoses.

**7-5.4.3** For biomass handling structures and conveyors, refer to 5-4.6.

NOTE: Conveyors can be considered protected by overhead sprinklers if not enclosed or hooded.

**7-5.4.4** Biomass storage buildings should be provided with automatic sprinklers throughout. Systems should be designed for a minimum of 0.25 gpm ft<sup>2</sup> (10.19 L min<sup>-1</sup> m<sup>-2</sup>) over the most remote 3000 ft<sup>2</sup> (279 m<sup>2</sup>) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft<sup>2</sup> (12.0 m<sup>2</sup>).

NOTE: Biomass fuels exhibit a wide range of burning characteristics and upon evaluation can require increased levels of protection.

**7-5.4.5** Based on the combustible loading, location, and essential use, an automatic sprinkler system should be considered for dust collectors, baghouses, and cyclone type separators. See 5-4.6.5.

**7-5.4.6** Hydraulic equipment, reservoirs, coolers, and associated oil filled equipment should be provided with automatic sprinkler or water spray protection. Sprinklers or spray nozzles should be over oil containing equipment and for 20 ft (6.1 m) beyond in all directions. A density of 0.25 gpm ft<sup>2</sup> (10.19 L min<sup>-1</sup> m<sup>-2</sup>) should be provided.

*Exception: Where a listed fire resistant fluid is used, protection is not needed.*

**7-5.5 Explosion Protection.** Biomass units utilizing equipment capable of producing explosive concentrations of gases or dusts as described in 7-5.2.3 should be provided with explosion venting or explosion suppression systems. For further guidance see NFPA 68, *Guide for Venting of Deflagrations*, NFPA 69, *Standard on Explosion Prevention Systems*, and NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*.

### **7-6 Rubber Tires.**

#### **7-6.1 General.**

**7-6.1.1** This section (Section 7-6) identifies fire and explosion hazards that are unique to the processing of rubber tires as a primary or secondary boiler fuel by means of

a process that can include, but is not limited to, storing, shredding, and conveying the rubber tires to a fuel storage area (and conveying it from the storage area to fuel the boiler).

NOTE: In general, rubber tires have a Btu content of 15,000 Btus per pound, roughly two to three times that of wood or RDF.

**7-6.1.2** There are several inherent fire hazards associated with scrap tires, whether outside or inside a building. Once tires are ignited, the fire develops rapidly, and it is difficult to extinguish. The tires will generate a large amount of black smoke. In addition, as the tires burn they generate oil that can spread and increase the size of the fire.

**7-6.1.3 Hazards Associated with Scrap Rubber Tires.** The major fire and explosion hazards associated with scrap rubber tire units are:

- (a) Storage of large quantities of tires, whether inside or outside;
- (b) Fast developing and rapidly spreading fire that burns for an extended period of time;
- (c) Hampering of fire fighting due to the generation of large amounts of black smoke and water pollution from runoff;
- (d) Unsuitable material entering the processing stream;
- (e) Large amounts of scrap tires accumulating in unsuitable areas as a result of spillage, handling, and processing;
- (f) Inadequate dust control.

## **7-6.2 Plant Arrangement.**

**7-6.2.1** The initial receiving and storage areas should be located outdoors. The area should be secured and cleared of all vegetation within 100 ft (30.5 m) of tire storage. See Appendix C of NFPA 231D, *Standard for Storage of Rubber Tires*, for further guidance on pile size, separation, and access.

**7-6.2.2** The boiler feed equipment, such as a metering bin, should be of noncombustible material and designed to minimize pockets or corners that would cause combustible material to build up. Video monitoring should be considered for locations not readily visible to plant staff. Refer to NFPA 8501, *Standard for Single Burner Boiler Operation*; NFPA 85C, *Standard for the Prevention of Furnace Explosions, Implosions in Multiple Burner Boiler-Furnaces*; NFPA 8503, *Standard for Pulverized Fuel Systems*; NFPA 85H, *Standard for the Prevention of Combustion Hazards in Atmospheric Fluidized Bed Combustion System Boilers*; and NFPA 8505, *Recommended Practice for Stoker Operation*.

**7-6.2.3** When overhead cranes are used to load inside feed hoppers from inside the storage pits, the following should be considered:

- (a) Locating the pulpit so that operator safety is not compromised.
- (b) The ability to have a clear and unobstructed view of all storage and charging areas.

NOTE: For additional guidance on cranes and storage pits, refer to 7-4.2.

**7-6.2.4** For tire plant processes that generate dust explosion potential, refer to NFPA 68, *Guide for Venting of Deflagrations*, NFPA 69, *Standard on Explosion Prevention Systems*, and individuals having specialized experience.

**7-6.2.5** Smoke or heat vents should be considered in accordance with 3-4.1.

## **7-6.3 Prevention of Fires and Explosion in Scrap Rubber Tires.**

**7-6.3.1** A communication system should be provided between facility personnel and the control room to expedite assistance in the event of fire.

**7-6.3.2** The facility personnel should ensure that scrap tires are continuously moved to the processing or storage areas. Vehicles loaded with scrap tires should not be parked in the building during idle periods.

**7-6.3.3** A regular program of housekeeping should be established to keep concentrations of combustible material to a minimum.

NOTE: For additional guidance, see Appendix C of NFPA 231D, *Standard for Storage of Rubber Tires*.

**7-6.3.4** The process should be designed to minimize the production of dust. Dust collected in a dust collection system, baghouse, or cyclone should be discharged downstream of the collection system, back to the conveying system, or back to the residue or waste stream. For additional guidance, see 5-4.3.4.

## **7-6.4 Fire Protection.**

**7-6.4.1** For the water supply and fire protection requirements of outdoor storage of scrap rubber tires, see Appendix C of NFPA 231D, *Standard for Storage of Rubber Tires*.

**7-6.4.2** Hose stations designed in accordance with NFPA 14 should be located throughout the facility. The following points should be considered:

- (a) Location and physical protection so as to avoid potential damage due to traffic patterns;
- (b) Size and number to be determined for unique plant geometry (e.g., push walls);
- (c) Protection from freezing in unheated areas;

NOTE 1: Hose stations are considered essential for final fire control and extinguishment. Addition of foam to hose streams should be considered.

NOTE 2: Plant geometry, combustible loading, and staffing may indicate that the use of 250 gpm monitor nozzles, in lieu of or in conjunction with hoses is acceptable.

**7-6.4.3** Based upon the combustible loading, location, and essential use, an automatic sprinkler system should be considered for dust collectors, baghouses, and cyclone type separators. See 5-4.6.5.

**7-6.4.4** For scrap rubber tire handling structures and conveyors, refer to 5-4.6.

NOTE: Experience indicates that sprinkler systems may not be effective and that foam-water spray systems are preferred for fire control. These systems are intended to confine the fire, and manual fire fighting may be required. Guidance should be sought from individuals having specialized experience for the selection of foam and foam application devices.

**7-6.4.5** The scrap rubber tire pit should be provided with foam-water spray protection throughout. The system(s) should be designed for a minimum of 0.24 gpm/ft<sup>2</sup> (9.77 L/min-m<sup>2</sup>) over the entire pit area with the protection area per nozzle not to exceed 100 ft<sup>2</sup> (9.3 m<sup>2</sup>).

CAUTION: Due to the extreme hazard, clearance between the top of storage and foam-water spray systems should be minimized.

**7-6.4.6** In addition to the foam-water spray protection, the storage pit should be provided with monitor nozzle protection designed to furnish a minimum of 250 gpm (946 L/min) at 100 psi (689 Pa) at the tip. Monitors should be located so as to allow for coverage of all pit areas with at least two streams operating simultaneously. Due to the potential for operator fire exposure, oscillating monitor nozzles with manual override should be provided.

NOTE: Addition of foam to the monitor nozzles should be considered.

**7-6.4.7** For protection and storage of scrap rubber tires indoors, refer to NFPA 231D.

**7-6.4.8** The boiler's tire feed system, including bins, hoppers, and chutes, should be considered for automatic foam-water protection. Where provided, the system should be designed for a minimum of 0.30 gpm/ft<sup>2</sup> (12.22 L/min-m<sup>2</sup>) over the most remote 2,500 ft<sup>2</sup> (232 m<sup>2</sup>).

**7-6.4.9** All water spray systems should be capable of remote actuation from the control room or other constantly attended areas. Additionally, local actuation stations should be placed adjacent to the fire areas along lines of egress and in consideration of operator safety and protection from damage due to equipment.

**7-6.4.10** Hydraulic equipment, reservoirs, coolers, and associated oil filled equipment should be provided with automatic sprinkler or water spray protection. Sprinklers or spray nozzles should be over oil containing equipment and for 20 ft (6.1 m) beyond in all directions. A density of 0.25 gpm/ft<sup>2</sup> (10.19 L/min-m<sup>2</sup>) should be provided.

Exception: Where a listed fire resistant fluid is used, protection is not needed.

**7-6.4.11** Particular care should be taken in the selection of detection devices in consideration of harsh and dusty environments and high air flows.

**7-6.5 Explosion Protection.** Scrap rubber tire units utilizing equipment capable of producing explosive concentrations of gases or dusts should be provided with explosion venting or explosion suppression systems. For further

guidance, see NFPA 68, *Guide for Venting of Deflagrations*, and NFPA 69, *Standard on Explosion Prevention Systems*.

**7-7 Other Alternative Fuels and Processes.** Other alternative fuels (e.g., culm, peat, gob, etc.) are used as boiler fuels. Also, other technologies exist for the utilization and processing of alternative fuels as boiler fuels. It is recommended that designers seek guidance from those having specialized experience to understand the unique characteristics of any particular fuel or technology in order to properly apply the appropriate portions of this and other applicable documents.

## Chapter 8 Fire Protection for the Construction Site

### 8-1 Introduction.

**8-1.1** Although many of the activities on fossil-fueled electric generating plant construction sites are similar to the construction of other large industrial plants, an above average level of fire protection is justified due to life safety consideration of the large number of on-site personnel, high value of materials, and length of the construction period. Consideration of fire protection must include safety to life, potential for delays in construction schedules and plant startup, as well as protection of property.

**8-1.2** Major construction projects in existing plants present many of the hazards associated with new construction while presenting additional exposures to the existing facility. The availability of the existing plant fire protection equipment and the reduction of fire exposure by construction activities are particularly important.

**8-1.3** For fire protection for plants and areas under construction, see NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*. This chapter addresses concerns not specifically considered in NFPA 241.

### 8-2 Administration.

**8-2.1** The responsibility for fire prevention and fire protection for the entire site during the construction period should be clearly defined. The administrative responsibilities should be to develop, implement, and periodically update as necessary the measures outlined in this recommended practice.

**8-2.2** The responsibility for fire prevention and fire protection programs among various parties on site should be clearly delineated. The fire protection program that is to be observed and the owner's right to administration and enforcement should be established.

**8-2.3** The fire prevention and fire protection program should include a fire risk evaluation of the construction site and construction activities at any construction camp (see Chapter 2).

**8-2.4** Written procedures should be established for the new construction site, including major construction projects in existing plants. Such procedures should be in accordance with Sections 2-4, 2-5, 2-6, 2-7, and 2-8.

**8-2.5** Security guard service, including recorded rounds, should be provided through all areas of construction during times when construction activity is not in progress (see NFPA 601, *Standard on Guard Service in Fire Loss Prevention*).

(a) The first round should be conducted one half hour after the suspension of work for the day. Thereafter, rounds should be made every hour.

(b) Where partial construction activities occur on second and third shifts, the guard service rounds may be modified to include only unattended or sparsely attended areas.

(c) In areas where automatic fire detection or extinguishing systems are in service, with alarm annunciation at a constantly attended location, or in areas of limited combustible loading, rounds may be omitted after the first round indicated in (a) above.

**8-2.6** Construction schedules should be coordinated so that planned permanent fire protection systems are installed and placed in service as soon as possible, at least prior to the introduction of any major fire hazards identified in Chapter 5.

**8-2.7** In-service fire detection and fire extinguishing systems provide important protection for construction materials, storage, etc., even before the permanent hazard is present. Temporary fire protection systems may be warranted during certain construction phases. The need and type of protection should be determined by the individual responsible for fire prevention and fire protection.

**8-2.8** Construction and installation of fire barriers and fire doors should be given priority in the construction schedule.

### **8-3 Site Clearing and Construction Equipment.**

#### **8-3.1 Site Clearing.**

**8-3.1.1** Prior to clearing forest and brush covered areas, the owner should ensure that a written fire control plan is prepared and that fire fighting tools and equipment are made available as recommended by NFPA 295, *Standard for Wildfire Control*. Contact should be made with local fire and forest agencies for current data on restrictions and fire potential, and to arrange for necessary permits.

**8-3.1.2** All construction vehicles and engine-driven portable equipment should be equipped with effective spark arrestors. Vehicles equipped with catalytic converters should be prohibited from wooded and heavily vegetated areas.

**8-3.1.3** Fire tools and equipment should be used for fire emergencies only and should be distinctly marked.

**8-3.1.4** Each site utility vehicle should be equipped with at least one fire fighting tool, portable fire extinguisher, or backpack pump filled with 4 to 5 gal (15 to 19 L) of water.

**8-3.1.5** Cut trees, brush, and other combustible spoil should be disposed of promptly.

**8-3.1.6** Where it is necessary to dispose of combustible waste by onsite burning, designated burning areas should be established with approval by the owner and should be in

compliance with federal, state, and local regulations and guidelines. The contractor should coordinate burning with the agencies responsible for monitoring fire danger in the area and obtain all appropriate permits prior to the start of work (see Section 8-2).

**8-3.1.7** Local conditions may require the establishment of fire breaks by clearing or use of selective herbicides in areas adjacent to property lines and access roads.

**8-3.2 Construction Equipment.** Construction equipment should meet the requirements of NFPA 512, *Standard for Truck Fire Protection*.

### **8-4 Construction Warehouses, Shops, and Offices.**

**8-4.1** All structures that are to be retained as part of the completed plant should be constructed of materials as indicated in Chapter 3 and should be in accordance with other recommendations for the completed plant.

**8-4.2** Construction warehouses, offices, trailers, sheds, and other facilities for the storage of tools and materials should be located with consideration of their exposure to major plant buildings or other important structures. For guidance in separation and protection see NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*.

**8-4.3** Large central office facilities may be of substantial value and contain high value computer equipment, irreplaceable construction records, or other valuable contents, the loss of which may result in significant construction delays. An analysis of fire potential should be performed. This analysis may indicate a need for automatic sprinkler systems or other protection or the desirability of subdividing the complex to limit values exposed by one fire.

**8-4.4** Warehouses that contain high value equipment (as defined by the individual responsible for fire prevention and fire protection), or where the loss of or damage to contents would cause a delay in startup dates of the completed plant, should be arranged and protected as indicated below. Although some of these structures are considered to be "temporary" and will be removed upon completion of the plant, the fire and loss potential should be thoroughly evaluated and protection provided where warranted.

**8-4.4.1** Building construction materials should be non-combustible or limited combustible. See Chapter 3.

**8-4.4.2** Automatic sprinkler systems should be designed and installed in accordance with the applicable NFPA standards. Waterflow alarms should be provided and located so as to be monitored at a constantly attended location as determined by the individual responsible for fire prevention and fire protection.

**8-4.4.3** Air-supported structures sometimes are used to provide temporary warehousing space. Although the fabric envelope may be a fire retardant material, the combustibility of contents and the values must be considered, as with any other type of warehouse. Because it is impractical to

provide automatic sprinkler protection for them, air-supported structures should be used only for noncombustible storage. An additional consideration is that relatively minor fire damage to the fabric envelope may leave the contents exposed to the elements.

**8-4.5** Temporary enclosures, including trailers, inside permanent plant buildings should be prohibited except where permitted by the individual responsible for fire prevention and fire protection. Where the floor area of a combustible enclosure exceeds 100 sq ft (9.29 m<sup>2</sup>) or where the occupancy presents a fire exposure, the enclosure should be protected with an approved automatic fire extinguishing system.

**8-4.6** Storage of construction materials, equipment, or supplies that are either combustible or in combustible packaging should be prohibited in main plant buildings unless:

(a) An approved automatic fire extinguishing system is in service in the storage area, or

(b) Where loss of the materials or loss to the surrounding plant area would be minimal, as determined by the individual responsible for fire prevention and fire protection.

**8-4.7** Construction camps comprised of mobile buildings arranged with the buildings adjoining each other to form one large fire area should be avoided. If buildings cannot be adequately separated, consideration should be given to installing fire walls between units or installing automatic sprinklers throughout the buildings.

**8-4.8** Fire alarms should be connected to a constantly attended central location.

**8-4.9** The handling, storage, and dispensing of flammable liquids and gases should meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*; NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*; and NFPA 395, *Standard for the Storage of Flammable and Combustible Liquids on Farms and Isolated Construction Projects*.

**8-4.10** Vehicle repair facilities should meet the requirements of NFPA 88B, *Standard for Repair Garages*.

## **8-5 Construction Site Lay-Down Areas.**

**8-5.1** Fire hydrant systems with an adequate water supply should be provided in lay-down areas where the need is determined by the individual responsible for fire prevention and fire protection.

**8-5.2** Combustible materials should be separated by a clear space to allow access for manual fire fighting equipment (see Section 8-8). Access should be provided and maintained to all fire fighting equipment including fire hoses, extinguishers, and hydrants.

## **8-6 Temporary Construction Materials.**

**8-6.1** Noncombustible or fire retardant scaffolds, form work, decking, and partitions should be used both inside and outside of permanent buildings where a fire could cause substantial damage or delay construction schedules.

**8-6.1.1** The use of noncombustible or fire retardant concrete form work is especially important for large structures (e.g., turbine-generator pedestal) where large quantities of forms are used.

**8-6.1.2** The use of listed pressure-impregnated fire retardant lumber or listed fire retardant coatings generally would be acceptable. Pressure-impregnated fire retardant lumber must be used in accordance with its listing and manufacturer's instructions. Where exposed to the weather or moisture (e.g., concrete forms), the fire retardant used must be suitable for this exposure. Fire retardant coatings are not acceptable on walking surfaces or surfaces subject to mechanical damage.

**8-6.2** Tarpaulins and plastic films should be of listed weather resistant and fire retardant materials (see NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films*).

## **8-7 Underground Mains, Hydrants, and Water Supplies.**

### **8-7.1 General.**

**8-7.1.1** Where practical, the permanent underground yard system, fire hydrants, and water supply (at least one water source), as indicated in Chapter 4, should be installed during the early stages of construction. Where provision of all or part of the permanent underground system and water supply is not practical, temporary systems should be provided. Temporary water supplies should be hydrostatically tested, flushed, and arranged to maintain a high degree of reliability, including protection from freezing and loss of power.

**8-7.1.2** The necessary reliability of construction water supplies, including redundant pumps, arrangement of power supplies, and use of combination service water and construction fire protection water, should be determined by the individual responsible for fire prevention and fire protection.

**8-7.2** Hydrants should be installed, as indicated in Chapter 4, in the vicinity of main plant buildings, important warehouses, office or storage trailer complexes, and important outside structures with combustible construction or combustible concrete form work (e.g., cooling towers). Where practical, the underground main should be arranged to minimize the possibility that any one break will remove from service any fixed water extinguishing system or leave any area without accessible hydrant protection.

**8-7.3** A fire protection water supply should be provided on the construction site and should be capable of furnishing the largest of the following for a minimum 2-hr duration:

(a) 750 gpm (47.3 L/sec), or

(b) The in-service fixed water extinguishing system with the highest water demand and 500 gpm (31.5 L/sec) for hose streams.

**8-7.3.1** The highest water demand should be determined by the hazards present at the stage of construction, which may not correspond with the highest water demand of the completed plant.



**8-7.3.2** As fixed water extinguishing systems are completed, they should be placed in service, even when the available construction phase fire protection water supply is not adequate to meet the system design demand. The extinguishing system will at least provide some degree of protection, especially where the full hazard is not yet present. However, when the permanent hazard is introduced, the water supply should be capable of providing the designed system demand. When using construction water in permanent systems, adequate strainers should be provided to prevent clogging of the system by foreign objects and dirt.

**8-7.3.3** The water supply should be sufficient to provide adequate pressure for hose connections at the highest elevation.

### **8-8 Manual Fire Fighting Equipment.**

**8-8.1** First aid fire fighting equipment should be provided, in accordance with NFPA 600, *Standard on Industrial Fire Brigades* and NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*.

NOTE: Mobile fire fighting equipment can be utilized to provide necessary first aid fire fighting equipment.

**8-8.2** Portable fire extinguishers of suitable capacity should be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*, where:

- (a) Flammable liquids are stored or handled,
- (b) Combustible materials are stored,
- (c) Temporary oil- or gas-fired equipment is used,
- (d) A tar or asphalt kettle is used, or
- (e) Welding or open flames are in use.

**8-8.3** Hoses and nozzles should be available at strategic locations, such as inside hose cabinets or hose houses or on dedicated fire response vehicles.

**8-8.4** If fire hose connections are not compatible with local fire fighting equipment, adapters should be made available.

## **Chapter 9 Referenced Publications**

**9-1** The following documents or portions thereof are referenced within this recommended practice and should be considered part of the recommendations of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

**9-1.1 NFPA Publications.** National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1990 edition

NFPA 11, *Standard for Low Expansion Foam and Combined Agent Systems*, 1988 edition

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, 1988 edition

NFPA 11C, *Standard for Mobile Foam Apparatus*, 1990 edition

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 1989 edition

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 1992 edition

NFPA 12B, *Standard on Halon 1211 Fire Extinguishing Systems*, 1990 edition

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1991 edition

NFPA 13A, *Recommended Practice for the Inspection, Testing, and Maintenance of Sprinkler Systems*, 1987 edition

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 1990 edition

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 1990 edition

NFPA 16, *Standard on the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*, 1991 edition

NFPA 16A, *Recommended Practice for the Installation of Closed-Head Foam-Water Sprinkler Systems*, 1988 edition

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 1990 edition

NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, 1990 edition

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 1987 edition

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 1992 edition

NFPA 26, *Recommended Practice for the Supervision of Valves Controlling Water Supplies for Fire Protection*, 1988 edition

NFPA 30, *Flammable and Combustible Liquids Code*, 1990 edition

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 1992 edition

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 1990 edition

NFPA 46, *Recommended Safe Practice for Storage of Forest Products*, 1990 edition

NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, 1989 edition

- NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites*, 1989 edition
- NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*, 1989 edition
- NFPA 54, *National Fuel Gas Code*, 1992 edition
- NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, 1992 edition
- NFPA 61B, *Standard for the Prevention of Fires and Explosions in Grain Elevators and Facilities Handling Bulk Raw Agricultural Commodities*, 1989 edition
- NFPA 68, *Guide for Venting of Deflagrations*, 1988 edition
- NFPA 69, *Standard on Explosion Prevention Systems*, 1992 edition
- NFPA 70, *National Electrical Code*, 1993 edition
- NFPA 71, *Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service*, 1989 edition
- NFPA 72, *Standard for the Installation, Maintenance, and Use of Protective Signaling Systems*, 1990 edition
- NFPA 72E, *Standard on Automatic Fire Detectors*, 1990 edition
- NFPA 72G, *Guide for the Installation, Maintenance, and Use of Notification Appliances for Protective Signaling Systems*, 1989 edition
- NFPA 72H, *Guide for Testing Procedures for Local, Auxiliary, Remote Station, and Proprietary Protective Signaling Systems*, 1988 edition
- NFPA 75, *Standard for the Protection of Electronic Computer Data Processing Equipment*, 1992 edition
- NFPA 77, *Recommended Practice on Static Electricity*, 1988 edition
- NFPA 80, *Standard for Fire Doors and Fire Windows*, 1992 edition
- NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, 1987 edition
- NFPA 85C, *Standard for Prevention of Furnace Explosions Implosions in Multiple Burner Boiler-Furnaces*, 1991 edition
- NFPA 88B, *Standard for Repair Garages*, 1991 edition
- NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, 1989 edition
- NFPA 90B, *Standard for the Installation of Warm Air Heating and Air Conditioning Systems*, 1989 edition
- NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*, 1992 edition
- NFPA 92A, *Recommended Practice for Smoke Control Systems*, 1988 edition
- NFPA 101, *Life Safety Code*, 1991 edition
- NFPA 204M, *Guide for Smoke and Heat Venting*, 1991 edition
- NFPA 214, *Standard on Water-Cooling Towers*, 1992 edition
- NFPA 220, *Standard on Types of Building Construction*, 1992 edition
- NFPA 231, *Standard for General Storage*, 1990 edition
- NFPA 231C, *Standard for Rack Storage of Materials*, 1991 edition
- NFPA 231D, *Standard for Storage of Rubber Tires*, 1989 edition
- NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*, 1989 edition
- NFPA 251, *Standard Methods of Fire Tests of Building Construction and Materials*, 1990 edition
- NFPA 252, *Standard Methods of Fire Tests of Door Assemblies*, 1990 edition
- NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*, 1990 edition
- NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, 1990 edition
- NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*, 1987 edition
- NFPA 257, *Standard for Fire Tests of Window Assemblies*, 1990 edition
- NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 1987 edition
- NFPA 295, *Standard for Wildfire Control*, 1991 edition
- NFPA 299, *Standard for Protection of Life and Property from Wildfire*, 1991 edition
- NFPA 395, *Standard for the Storage of Flammable and Combustible Liquids on Farms and Isolated Construction Projects*, 1988 edition
- NFPA 512, *Standard for Truck Fire Protection*, 1990 edition
- NFPA 600, *Standard on Industrial Fire Brigades*, 1992 edition
- NFPA 601, *Standard on Guard Service in Fire Loss Prevention*, 1992 edition

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, 1987 edition

NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films*, 1989 edition

NFPA 780, *Lightning Protection Code*, 1992 edition

NFPA 803, *Standard for Fire Protection for Light Water Nuclear Power Plants*, 1988 edition

NFPA 851, *Recommended Practice for Fire Protection for Hydroelectric Generating Plants*, 1992 edition

NFPA 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems*, 1991 edition

NFPA 1962, *Standard for the Care, Use, and Maintenance of Fire Hose Including Couplings and Nozzles*, 1988 edition

NFPA 1972, *Standard on Helmets for Structural Fire Fighting*, 1992 edition

NFPA 8501, *Standard for Single Burner Boiler Operation*, 1992 edition

NFPA 8503, *Standard for Pulverized Fuel Systems*, 1992 edition

NFPA 8505, *Recommended Practice for Stoker Operation*, 1992 edition

## 9-1.2 Other Publications.

**9-1.2.1 ANSI Publications.** American National Standards Institute Inc., 1450 Broadway, New York, NY 10018.

ANSI A14.3, *Standard for Safety Requirements for Fixed Ladders*, 1984

ANSI B133.4, *Gas Turbine Control and Protection Systems*, 1978

ANSI B31.1, *Code for Power Piping*, 1989

ANSI C2, *National Electrical Safety Code*, 1981

ANSI Z210.1, *Metric Practice Guide*

**9-1.2.2 ASTM Publications.** American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19105.

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*

ASTM E380 (see ANSI Z210.1)

ASTM E814, *Fire Tests of Through-Penetration Fire Stops*

**9-1.2.3 IEEE Publications.** Institute of Electrical and Electronics Engineers, 345 East 47 St., New York, NY 10070.

IEEE 383, *Standard for Type Test of Class IE Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations*

IEEE 484, *Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations*

IEEE 634, *Testing of Fire Rated Penetration Seals*

IEEE 979, *Guide for Substation Fire Protection*

**9-1.2.4 OSHA Publication.** Occupational Safety and Health Administration, Washington, DC.

29 CFR 1910.156, *Fire Brigades*, 1986

**9-1.2.5 EPRI Publication.** Electric Power Research Institute, 3412 Hillview Avenue, P.O. Box 10412, Palo Alto, CA 94303.

EPRI Research Project 1843-2, *Turbine Generator Fire Protection by Sprinkler System*, July 1985

**9-1.2.6 UL Publication.** Underwriters Laboratories Inc., 333 Plingsten Road, Northbrook, IL 60062.

UL 900, *Standard for Safety Test Performance of Air Filters*, 1987

## 9-2 Related Publications.

**9-2.1 ANSI Publications.** American National Standards Institute Inc., 1450 Broadway, New York, NY 10018.

ANSI B133.3, *Procurement Standard for Gas Turbine Auxiliary Equipment* - 1981

ANSI B133.4, *Gas Turbine Control and Protection Systems* - 1978

ANSI B133.5, *Procurement Standard for Gas Turbine Electrical Equipment* - 1978

ANSI-ASME B133.7M, *Gas Turbine Fuels* - 1985

ANSI B133.10, *Procurement Standard for Gas Turbine Information to be Supplied by User or Manufacturer* - 1981

ANSI B133.11, *Procurement Standard for Gas Turbine Preparation for Shipping and Installation* - 1982

ANSI B133.12, *Procurement Standard for Gas Turbine Maintenance and Safety* - 1981