NFPA 850

Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations

1996 Edition

NFPA®

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

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This edition of NFPA 850, *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations*, was prepared by the Technical Committee on Electric Generating Plants and acted on by the National Fire Protection Association, Inc., at its Fall Meeting held November 13-15, 1995, in Chicago, IL. It was issued by the Standards Council on January 12, 1996, with an effective date of February 2, 1996, and supersedes all previous editions.

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.

This edition of NFPA 850 was approved as an American National Standard on February 2, 1996.

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.

The 1992 edition of NFPA 850 incorporated 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.

This 1996 edition of the standard added a new Chapter 8 on Fire Protection for High Voltage Direct Current (HVDC) converter stations. In addition, the title was changed to *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations* to incorporate the new chapter.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in membership may have occurred. A key to classifications is found at the back of this document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on fire protection for electric generating plants and high voltage direct current (HVDC) converter stations, except for electric generating plants using nuclear fuel.

Contents

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix A.

Information on referenced publications can be found in Chapter 10 and Appendix E.

Chapter 1 Introduction

1-1 Scope. This document provides recommendations (not requirements) for fire prevention and fire protection for electric generating plants and high voltage direct current converter stations, except as follows: nuclear power plants are addressed in NFPA 803, *Standard for Fire Protection for Light Water Nuclear Power Plants*; hydroelectric plants are addressed in NFPA 851, *Recommended Practice for Fire Protection for Hydroelectric Generating Plants*; and combustion turbine and internal combustion engine units of 7500 hp or less are addressed in NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.*

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 electric generating plants, combustion turbine and internal combustion engine electric generating plants, and high voltage direct current converter stations. 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 for electric generating plants and high voltage direct current converter stations.

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 should 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.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

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/ft^2 (kJ/m^2).

Fire Point. The lowest temperature at which a liquid in an open container will give off sufficient vapors to burn 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 on Fire Test of Window and Glass Block 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-Resistant Fluid. A listed hydraulic fluid or lubricant that is difficult to ignite due to its high fire point and autoignition temperature and that does not sustain combustion due to its low heat of combustion.

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 Tests of Fire Endurance 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).

High Voltage Direct Current (HVDC) Converter Station. A facility that functions as an electrical rectifier (ac-dc) or an inventor (dc-ac) to control and transmit power in a high voltage network. There are two types of HVDC valves: the mercury arc valve and the present day technology solid state thyristor valve. Both types of valves present a fire risk due to high voltage equipment that consists of oil-filled converter transformers, wall bushings, and capacitors in addition to various polymeric components.

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 when any element thereof, when 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 that is 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/lb (8.14×10^6 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 $^1/_8$ 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 the 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 are 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.

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 E 136, *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 ASTM E 380/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 and high voltage direct current converter stations.

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 ensure 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) Fire safety 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. Fire experience has shown that transient combustibles can be a significant factor during a fire situation, especially during outages.

(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 for Security Services in Fire Loss Prevention.*)

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

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.*)

NOTE: Inspection intervals for unattended plants may be permitted to 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:

(a) identify equipment not available for service;

(b) identify personnel to be notified (e.g., plant fire brigade chief, public fire department, etc.); and

(c) increase fire surveillance as needed. [*See 2-4(f).*]

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

Item	NFPA No.
Supervisory and Fire Alarm Circuits	72
Fire Detectors	72
Manual Fire Alarms	72
Sprinkler Water Flow Alarms	25/72
Sprinkler and Water Spray Systems	15/25
Foam Systems	11A/11C/16
Halogenated Agent, Chemical & Co. Systems	12/12A/17
Fire Pumps & Booster Pumps	20
Water Tanks & Alarms	25/22/72
P.I.V.s and O.S. & Y. Valves	25/72
Fire Hydrants and Associated Valves	25/24
Fire Hose and Standpipes	14/1962
Portable Fire Extinguishers & Hose Nozzles	10/1962
Fire Brigade Equipment	1971/1972/1973/1974
Fire Doors	80
Smoke Vents	204M
Emergency Lighting	70
Radio Communication Equipment	1221
Audible and Visual Signals	72

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 should 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; and

(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 should 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; and

(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 D.*)

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.

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°F–3000°F (1537°C–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 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 permitted to 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 should 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 to75 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 8502, Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boilers, and NFPA 8503, Standard for Pulverized Fuel Systems.*)

2-9 Identification of Fire Hazards of Materials. Materials located in the plant or storage areas should be identified in accordance with NFPA 704, *Standard System for the Identification of the Fire Hazards of Materials.*

Chapter 3 General Plant Design

3-1 Plant Arrangement.

3-1.1 Fire Area Determination.

3-1.1.1 The electric generating plant and high voltage direct current converter station 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 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:

(a) types, quantity, density, and locations of combustible material;

(b) location and configuration of plant equipment;

(c) consequence of losing plant equipment; and

(d) location of fire detection and suppression systems.

3-1.1.3 Unless consideration of the factors of 3-1.1.2 indicates otherwise, it is recommended that fire area boundaries be provided to separate the following:

(a) cable spreading room(s) and cable tunnel(s) from adjacent areas;

(b) control room, computer room, or combined control/computer room from adjacent areas;

NOTE: Where the control room and computer room are separated by a common wall, the wall need not have a fire resistance rating.

(c) rooms with major concentrations of electrical equipment, such as switchgear room and relay room, from adjacent areas;

(d) battery rooms from adjacent areas;

(e) maintenance shop(s) from adjacent areas;

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

(g) fire pumps from adjacent areas;

(h) warehouses from adjacent areas;

(i) emergency diesel generators from each other and from adjacent areas;

(j) fossil fuel-fired auxiliary boiler(s) from adjacent areas;

(k) fuel oil pumping, fuel oil heating facilities, or both, used for continuous firing of the boiler from adjacent areas;

(l) storage areas for flammable and combustible liquid tanks and containers from adjacent areas;

(m) office buildings from adjacent areas;

(n) telecommunication rooms from adjacent areas; and

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

3-1.1.4 Fire barriers separating fire areas should be a minimum of 2-hr fire resistance rating.

3-1.1.5 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].

3-1.2 Openings in Fire Barriers.

3-1.2.1 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 E 814, *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 permitted to be considered for this application.

NOTE 1: Listed penetration seals for large diameter piping may not be commercially available. In such instances the design should be similar to listed configurations.

NOTE 2: Listed penetration seals for the internals of non-segregated phase bus ducts and isolated phase bus ducts can be excluded.

3-1.2.2 Fire door assemblies, fire dampers, and fire shutters used in 2-hr rated fire barriers should be rated not less than $1^1/_2$ hr. (*See NFPA 80, Standard for Fire Doors and Fire Windows.*)

3-1.3 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.*)

3-1.4 Outdoor Oil-Insulated Transformers.

3-1.4.1 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.

3-1.4.2 Determination of the type of physical separation to be used should be based on consideration of the following:

(a) type and quantity of oil in the transformer;

(b) size of a postulated oil spill (surface area and depth);

(c) type of construction of adjacent structures;

(d) power rating of the transformer;

(e) fire suppression systems provided; and

(f) type of electrical protective relaying provided.

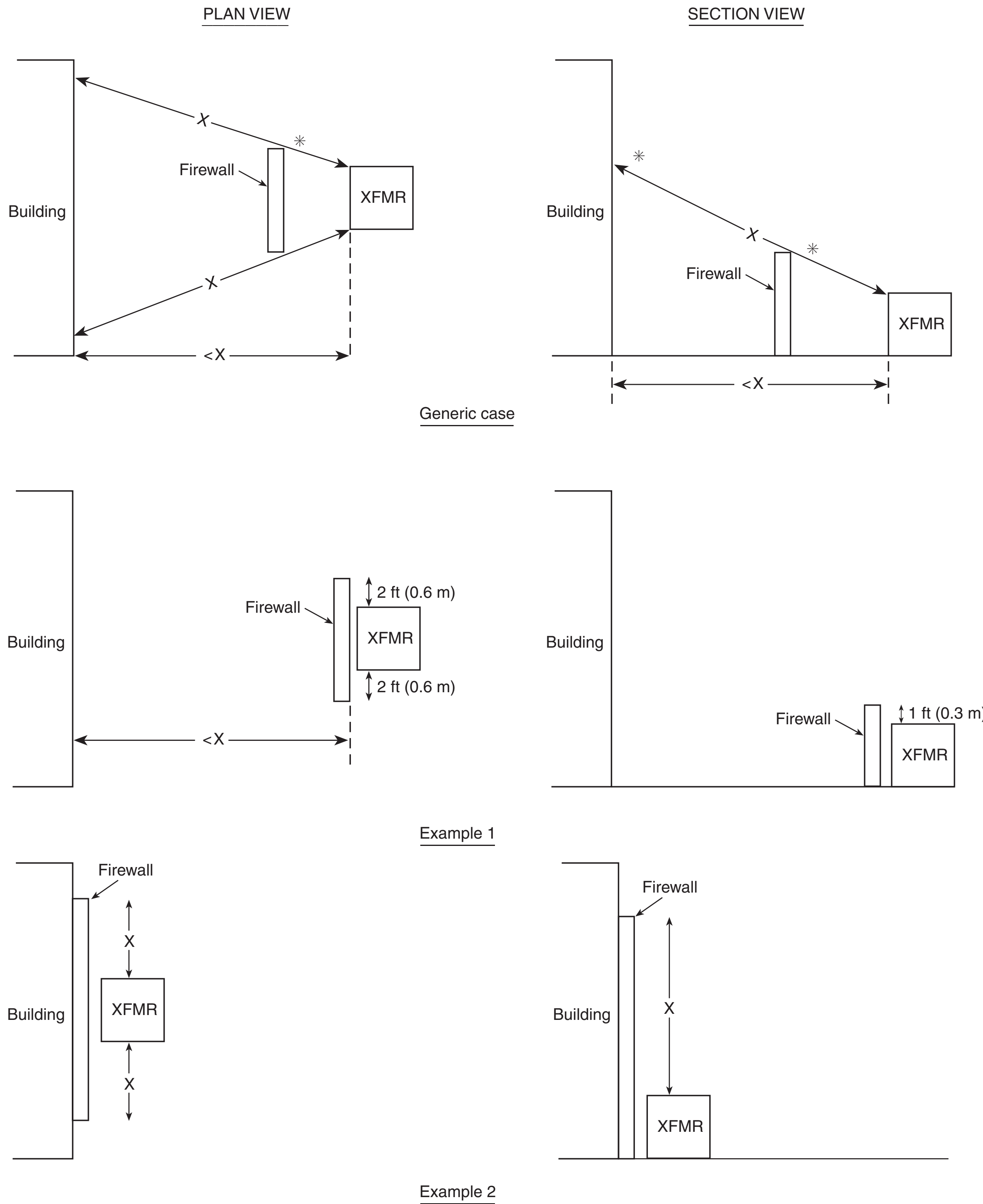
3-1.4.3 Unless consideration of the factors in 3-1.4.2 indicates otherwise, it is recommended that any oil-insulated transformer containing 500 gal (1893 L) or more of oil be separated from adjacent noncombustible or limited combustible structures by a 2-hr rated firewall or by spatial separation in accordance with Table 3-1.4.3. Where a firewall is provided between structures and a transformer, it should extend vertically and horizontally as indicated in Figure 3-1.4.3.

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 supporting the turbine building roof at the exterior wall have a 2-hr fire resistive rating above the operating floor, the firewall need not be higher than required to obtain line-of-sight protection to the height of the operating floor.

Table 3-1.4.3 Outdoor Oil Insulated Transformer Separation Criteria

Transformer Oil Capacity	Minimum (Line-of-Sight) Separation without Firewall
Less than 500 gal (1893 L)	See 3-1.4.2
500 gal to 5000 gal (1893 L to 18,925 L)	25 ft (7.6 m)
Over 5000 gal (18,925 L)	50 ft (15 m)



Notes:
X = Minimum separation distance from Table 3-1.4.3.
✳ = See Notes in 3-1.4.3.

Figure 3-1.4.3 Outdoor oil-insulated transformer separation criteria.

3-1.4.4 Unless consideration of the factors in 3-1.4.2 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 3-1.4.3. 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.

3-1.4.5 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 permitted to be provided to protect against the effects of an exploding transformer bushing.

3-1.4.6 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.

3-1.4.7 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 3-1.4.2 and 3-1.4.5.

3-1.5 Indoor Transformers.

3-1.5.1 Dry-type transformers are preferred for indoor installations.

3-1.5.2 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.

3-1.5.3 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.

3-1.5.4 Where transformers are protected by an automatic fire suppression system, the fire barrier fire resistance rating may be permitted to be reduced to 1 hr.

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*®.

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

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

NOTE 1: It generally is recognized that boiler and turbine buildings, protected in accordance with this document, meet the intent of NFPA *101*, *Life Safety Code*, for additional travel distances for fully sprinklered facilities.

NOTE 2: NFPA *101* allows additional means of egress components for special purpose industrial occupancies. These areas may be permitted to be provided with fixed industrial stairs, fixed ladders (*see ANSI A1264.1, Safety Requirements for Workplace Floor and Well Openings, Stairs, and Railing Systems and* ANSI A14.3, *Standard for Safety Requirements for Fixed Ladders*), or alternating tread devices (*see NFPA 101*). Examples of these spaces include catwalks, floor areas, or elevated platforms that are provided for maintenance and inspection of in-place equipment.

NOTE 3: Spaces internal to equipment and machinery are excluded from the requirements of NFPA *101*. Examples of these spaces include, but are not limited to, the internals of the following:

1. boilers;
2. scrubbers;
3. pulverizers;
4. combustion turbine enclosures;
5. cooling towers;
6. bunkers, silos, and hoppers;
7. conveyor pulley take-up areas; or
8. electrostatic precipitators.

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

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

(d) Warehouses should be considered as storage occupancies.

(e) Coal preparation and handling facilities (e.g., enclosed crusher houses, transfer houses, and conveyors) should be considered special purpose industrial occupancies.

(f) Scrubber buildings should be considered as special purpose industrial occupancies.

3-2.3 In the event of a plant fire, egress of occupants in control facilities may be delayed due to emergency shutdown procedures. Control facilities should have a means of egress that is separated from other plant areas to facilitate a delayed egress.

3-3 Building Construction Materials.

3-3.1 Construction materials being considered for electric generating plants and high voltage direct current converter stations 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 Tests of Fire Endurance 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, engine, or turbine-generator buildings or other buildings critical to power generation or conversion 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 or conversion should be Class A.

3-3.4.3 Interior finish in buildings not critical to power generation or conversion 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, and should not be used to assist such systems for comfort ventilation. Smoke and heat vents should not be left open where they can sustain damage from high wind conditions. They should be included in surveillance programs to ensure 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 permitted to 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 also may be permitted to 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 ensure 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 permitted to 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 permitted to 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 either be located so as to minimize the possibility of drawing products of combustion into the plant, or be provided with automatic closure on detection of smoke. Separation from exhaust air outlets, smoke vents from other areas, and outdoor fire hazards should all be considered.

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 where 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 that are not separated by a fire barrier [*see 3-1.1.3(o)*], provisions such as a sloped floor, 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 in 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, *Standard for the Installation of Lightning Protection Systems.*

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 1 or 2 below, whichever is larger:

1. The largest fixed fire suppression system demand,

2. 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 two-hour supply for the fire protection requirement in an eight-hour period. The eight-hour (time) requirement for refilling may be permitted to 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 where 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 permitted 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 can be isolated without interrupting service simultaneously to both fixed protection and hose connections protecting the same hazard or area. Choice of Class I, Class II, or Class III systems should be made by a 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, the 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, 7, and 8 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*

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 for 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 The selection of an extinguishing agent or a combination of extinguishing agents should be based on:

(a) The type of hazard;

(b) The effect of agent discharge on equipment;

(c) The 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 The type of protective signaling system for each installation and area should be determined by the Fire Risk Evaluation in consideration of hazards, arrangement, and fire suppression systems. Fire detection and automatic fixed fire suppression systems should be equipped with local audible and visual signals with annunciation in a constantly attended location, such as the main control room. Audible fire alarms should be distinctive from other plant system alarms. See NFPA 72, *National Fire Alarm Code.*

4-7.2 Automatic fire detectors should be installed in accordance with NFPA 72, *National Fire Alarm Code.*

4-7.3 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 or voice communication systems, or both, 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 The plant's main and ignitor natural gas shut-off valve should be located near an exterior wall. The valve should be provided with both manual and automatic closing capabilities locally, and remote closing capability from the control room. The valve should be arranged to fail closed on the loss of power or pneumatic control.

5-2.3 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®*, 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 the 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 fire safety.

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 ft^3 of exhaust air per ft^2 of floor area (0.30 m^3/m^2), but not less than 150 ft^3/min (0.071 m^3/sec).

5-3.9 Fire Protection.

5-3.9.1 Indoor fuel oil pumping or heating facilities or both should be protected with automatic sprinklers, water spray, foam-water sprinklers, or gaseous total flooding system(s). Local application dry chemical systems may be permitted to be used in areas that normally do not have re-ignition 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 manholes.

(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 8503, 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 During idle periods, flammable gas monitors can be installed at the top of the silo to monitor methane gas and carbon monoxide concentrations. Flammable gas monitors should be arranged to alert plant operators if methane concentrations are detected or carbon monoxide concentration exceeds 1.25 percent concentration by volume. Heat detectors can also be inserted to detect temperature increase due to spontaneous combustion.

5-4.2.5 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 might 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.

5-4.2.6* If fire occurs in a silo it is necessary to initiate manual actions for suppression and extinguishment. The following fire fighting strategies have been successfully employed (depending on the specific circumstances and type of coal used):

(a) Use of Class A foams and penetrants;

(b) Injection of inert gas (i.e., carbon dioxide or nitrogen);

(c) Emptying the silo through the feeder pipe to a safe location (inside or outside the powerhouse), and trucking away the debris.

NOTE: All signs of spontaneous combustion and fire must be eliminated prior to the movement of coal.

CAUTION:

1. Water has been successfully used to control bunker and silo fires. However, the possibility of an explosion exists under certain circumstances if the water reaches the coal in a hot spot. Therefore, water is not a recommended fire fighting strategy for these types of fire events. The amount of water delivered to a silo in a stream can create structural support problems.

2. Steam-smothering has also been used to control bunker and silo fires on marine vessels. All openings need to be sealed prior to the introduction of steam. This is rarely possible at electric generating plants due to the relatively porous nature of the equipment.

The use of steam introduces high temperature and moisture that could increase the possibility of spontaneous combustion; therefore, this strategy is not recommended.

3. Locating silo hot spots and extinguishing them before the coal leaves the silo is an accepted practice. The coal hot spots are detected and extinguished. If, as the coal drops down through the silo, additional hot spots are detected, coal flow should be stopped and the hot spots extinguished. If the hot spots are exposed during the lowering of the coal, potential for dust explosions is increased.

5-4.2.7 Care should be taken where 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.

5-4.2.8 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) a dust collection system;

(b) a dust suppression system;

(c) an 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 can reduce the need for dust collection.

5-4.3.3 Dust suppression systems usually consist of spray systems using water or surfactants, or both, 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 permitted to 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 an 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 where 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 Provisions 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 C2, National Electrical Safety Code.*)

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/ft^2 (0.17 L/sec-m^2) density over a 2500 ft^2 (232 m^2) 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^2 (0.17 L/sec-m^2) density over 2000 ft^2 (186 m^2) of enclosed area or the most remote 100 linear ft (30 m) of conveyor structure up to 2000 ft^2 (186 m^2). 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 should 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. The water supply could be from a 3000 gal to 5000 gal (11,355 L 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 providing 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 8502, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boilers.*

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^2 (0.17 L/sec-m^2) 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 permitted to 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. The use of a listed fire-resistant lubricant and hydraulic fluid can eliminate the need for fire protection systems.

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 bearings points and hot turbine parts should be considered. If necessary, these areas may be permitted to 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^2 (0.17 L/sec-m^2) over the oil containment equipment surface. Water spray systems should be designed for 0.25 gpm/ft^2 (0.17 L/sec-m^2) 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^2 (0.41 L/sec-m^2) density is recommended. Where the rotor or stator is vertical, water spray should be applied to both sides to obtain adequate penetration. A minimum of 0.30 gpm/ft^2 (0.20 L/sec-m^2) 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 the 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 Drainage should be provided to remove suppression water to a safe area. Drains from air heaters, 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 also may 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/ft^2 (0.14 L/sec-m^2) 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-furnace 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^2 (0.17 L/sec-m^2) over the exposed surface of the transformer-rectifier set. Automatic sprinkler systems should be designed for a density of 0.25 gpm/ft^2 (0.17 L/sec-m^2) over 3500 ft^2 (325 m^2). 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 3-1.4 and 3-1.5.*)

5-6.5* Scrubbers and Exhaust Ducts.

5-6.5.1 General. Fires have occurred in scrubbers with combustible lining, combustible packing, or both. The fires occurred during outages and were caused by cutting and welding. Attempts to manually fight the fires were not successful since smoke and heat prevented access to the scrubber. Where scrubbers were located in buildings, there has been extensive smoke and heat damage to the building. A fire also can occur in ducts with plastic or rubber lining.

5-6.5.2 Scrubber Buildings.

5-6.5.2.1 Buildings should be constructed of materials meeting the criteria outlined in Section 3-3.

5-6.5.2.2 Where scrubbers have plastic or rubber linings, one of the following methods of protection for the building should be provided:

(a) Automatic sprinkler protection at ceiling level sized to provide 0.20 gpm/ft^2 (0.14 L/sec-m^2). The area of operation should be the area of the building or 10,000 ft^2 (930 m^2). Where draft curtains are provided the area of operation can be reduced to the largest area subdivided by draft curtains.

(b) The roof deck and supporting steel should be protected with a 1-hr fire proof coating. Building columns should be protected with a 2-hr fire proof coating from the roof to 20 ft (6 m) below the roof. Columns adjacent to scrubber openings should be protected from the roof to below the opening scrubber opening. Automatic or remotely actuated heat venting should be provided with a vent area of 1 ft^2 per 50 ft^2 of floor area.

5-6.5.2.3 If a listed less flammable fluid is not used, hydraulic and lubricating oil equipment should be protected as described in 5-7.4.

5-6.5.3 Scrubbers.

5-6.5.3.1 Materials of Construction. Scrubbers, internal piping, and ducts should be constructed of noncombustible materials, or the recommendations of 5-6.5.3.2 and 5-6.5.3.3 should be incorporated.

5-6.5.3.2 During outages, all of the following should be done:

(a) Cutting, welding, and other hot work is the most likely cause of ignition. Thus, strict controls should be enforced. Packing should be covered with fire-resistant blankets over sheet metal. Blankets should be kept wet. A charged hose and fire watch should be provided at the work area.

(b) All equipment lined with combustible material should be identified with warning signs or placards.

(c) The scrubber reservoir should be maintained full if possible or returned to service as quickly as possible during an outage.

(d) The absorber inlet and outlet damper should be closed during cutting, welding, or other hot work to reduce the induced draft. When the scrubber outlet damper is open no work should be permitted in the downstream duct or stack.

5-6.5.3.3 Fire Protection. A fire protection system should be provided during outages for absorber vessels containing combustible packing or lining and should include the following:

(a) The fire protection system can be the spray system designed for normal scrubber operation or a specially designed fire protection system. Water spray systems should be designed such that spray patterns cover the lining and packing. Where scrubber spray systems are used for fire protection, system components internal to the scrubber should be noncombustible. The water supply should be from a reliable source available during the outage.

(b) Duct systems. A fire protection system should be provided during maintenance operations. A fixed protection system on the scaffolding is recommended. The system should be designed to protect the work platform and twice the area that can be reached by workers on the platform.

(c) Due to the unique design and operating features of scrubbers, fire protection designers should consult with the scrubber manufacturer for guidance as to material selection for internal fire protection systems and specific protection design features.

(d) Standpipes should be provided such that $1^1/_2$-in. (3.8-cm) hose is available at scrubber access hatches that are open during outages.

(e) Combustible materials in the scrubber should be limited and controlled during maintenance and inspection outages.

5-6.5.4 Limestone Conveyors. Limestone conveyors for use with flue gas desulfurization systems should meet the fire protection requirements of 5-4.4.1, 5-4.4.2, 5-4.4.3, and 5-4.5.1. Conveyors critical to continued plant operation should be provided with an automatic sprinkler or water spray system over the drive pulley, and a fire detection system should be provided and interlocked to shut down the conveyor.

5-6.6 Stacks.

5-6.6.1 Noncombustible liners should be used where practical. (*See Appendix C 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 where the generator is opened for maintenance.

5-7.1.5 For electrical equipment in the vicinity of the hydrogen handling equipment, including detraining 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 detraining 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 Lubricating oil storage, pumping facilities, and associated piping should comply with NFPA 30, *Flammable and Combustible Liquids Code.*

5-7.3.2 Turbine lubricating oil reservoirs should be provided with a vapor extractor, vented to a safe outside location.

5-7.3.3 Curbing or drainage or both should be provided for the turbine lubricating oil reservoir in accordance with Section 3-5.

5-7.3.4 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. (*See NFPA 30, Flammable and Combustible Liquids Code; Chapter 3, Piping Systems.*)

5-7.3.5 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.

5-7.3.6 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 the discussion in 2-7.2 on fire emergency planning involving turbine lubricating oil fires.

5-7.3.7 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 Turbine-Generator Area.

5-7.4.1.1 All areas beneath the turbine-generator operating floor that are subject to oil flow, oil spray, or oil 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/ft^2 (0.20 L/sec-m^2) over a minimum application of 5000 ft^2 (464 m^2).

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 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/ft^2 (0.20 L/sec-m^2).

5-7.4.1.3 Lubricating oil reservoirs and handling equipment should be protected in accordance with 5-7.4.1.1. If the lubricating oil equipment is in a separate room enclosure, protection may be provided by a total flooding gaseous extinguishing system.

NOTE 1: If the lubricating oil reservoir is elevated, sprinkler protection should be extended to protect the area beneath the reservoir.

NOTE 2: If the lubricating oil reservoirs and handling equipment are located on the turbine operating floor and not enclosed in a separate fire area, then all areas subject to oil flow or oil accumulation should be protected by an automatic sprinkler or deluge system.

5-7.4.1.4 Above the operating floor, ceiling level sprinkler systems may not be effective to protect floor level equipment and components from oil fires because of the high ceilings [typically in excess of 40 ft (12 m)]. More effective protection can be provided by containing oil spills and providing local automatic protection systems for the containment areas.

5-7.4.1.5 Foam-water sprinkler systems installed in place of automatic sprinklers described above should be designed in accordance with NFPA 16, *Standard for the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems* or NFPA 16A, *Standard for the Installation of Closed-Head Foam-Water Sprinkler Systems,* and the design densities specified above.

5-7.4.1.6 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/ft^2 (0.17 L/sec-m^2) 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 permitted to 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 Exciter. The area inside a directly connected exciter housing should be protected with a total flooding automatic carbon dioxide system.

5-7.4.4 Hydrogen Seal Oil. Hydrogen seal oil units should be protected in accordance with 5-7.4.1.

5-7.4.5 Oil Storage Areas. Clean or 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, or telecommunication rooms should meet the 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 permitted to 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, total flooding gaseous 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 and 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/ft^2 (0.20 L/sec-m^2) over 2500 ft^2 (232 m^2) or the most remote 100 linear ft (30 m) of cable tunnels up to 2500 ft^2 (232 m^2).

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 and 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 startup 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 (1893 L) of oil should be in accordance with 3-1.4. Consideration should be given to water spray protection of transformers critical to the transmission of the generated power.

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^2 (0.17 L/sec-m^2) 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 5-7.4.5.*)

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/ft^2 (0.17 L/sec-m^2) 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/ft^2 (0.17 L/sec-m^2) 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 buildings specifically designed and built or modified for the combustion turbine generator and its auxiliaries. Therefore, some recommendations may be more suitable for one type of plant than the other.

6-2 Application of Chapters 2 through 5 and Chapter 9. The recommendations contained in Chapters 2 through 5 and Chapter 9 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 and Internal Combustion Engine Generators.

6-5.1 General.

6-5.1.1 NFPA 37, *Standard for Installation and Use of Stationary Combustion Engines and Gas Turbines*, addresses engines and turbines not exceeding 7500 HP. It includes important items of design, siting, protective devices, and fueling that apply regardless of engine size.

6-5.1.2 Site specific design considerations or manufacturers typical design will govern what equipment has enclosures or how many separate enclosures will be provided for the combustion turbines or the diesel engines. 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. Smaller diesel engine plants might involve enclosures for equipment but more commonly engine generators are installed in a row in an open room or hall.

6-5.1.3 The major hazards associated with combustion turbine or diesel electric generator units are:

(a) Flammable and combustible fuels; and

(b) Hydraulic and lubricating oils.

6-5.1.4 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. Crankcase explosions in diesel engines have caused large external fires. Other hazards associated with the combustion turbine or internal combustion engine generator are:

(a) Electrical equipment; and

(b) Large amounts of filter media and enclosure insulation.

NOTE: Diesel electric plants do not normally use large amounts of filter media and enclosure insulation.

6-5.1.5 In the event of a problem with a diesel engine, shutdown may be difficult. Several different methods, operating independently, should be provided. These can include centrifugally tripped (over speed condition) spring operated fuel rack closure, governor fuel rack closure, electro-pneumatic fuel rack closure, or air inlet guillotine type air shutoff.

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 where 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; and

(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 and Diesel Engines.

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 For diesel engines, the following monitors should be provided:

(a) Speed sensors, independent of governors; and

(b) High exhaust gas temperature alarm with shutdown.

6-5.3.3 In many units the lubricating oil is used for both lubrication and hydraulic control. For combined systems, a listed fire-resistive fluid should be considered. If separate systems are used, the hydraulic control system should use a listed fire-resistive hydraulic fluid, and a listed fire-resistant fluid should be considered for the lubricating system.

NOTE: Diesel engines do not normally have any hydraulic systems.

6-5.3.4 Combustible gas detector(s) should be considered for the enclosure where the fuel for the gas turbine or diesel engine is natural gas or other gaseous-type fuels.

6-5.3.5 For recommendations regarding containment and drainage of liquids, see Section 3-5.

6-5.4 Fire Protection for Combustion Turbines and Diesel Electrical Generators.

6-5.4.1 General.

6-5.4.1.1 Determination of the need for fire suppression for the combustion turbine engine should be based on consideration of the value of the unit, consequences of loss of the unit, and vulnerability of adjacent structures and equipment to damage.

6-5.4.1.2 Water suppression systems, where provided, should follow the recommendations in Chapter 5 and the following criteria:

(a) Water spray nozzles provided to protect the combustion turbine power 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) Accidental water discharge on bearing points and hot turbine parts should be considered. If necessary, these areas can be protected by shields and encasing insulation with metal covers.

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

(e) Turbine chargers on diesel engines constitute a part of the hazard and protection should be provided.

6-5.4.1.3 Lubricating oil reservoirs and handling equipment should be protected in accordance with 5-7.3.2 and 5-7.4.1.3.

6-5.4.2 Total Flooding Gaseous Systems.

6-5.4.2.1 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 or diesel engine 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 or diesel engine air. This air flow will not stop immediately upon shutdown, and, therefore, it should be considered in the extinguishing system design.

6-5.4.2.2 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-minute time period in most turbine or engine compartments. Therefore, the designer should 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.

6-5.4.2.3 System operations should be arranged to close the fuel valves.

6-5.4.2.4 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.

6-5.4.2.5 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.

6-5.4.2.6 For combustion turbines or diesel engines located indoors, provisions should be addressed for safely removing the gas and potential toxic combustion by-products from the turbine enclosure following system actuation.

6-5.4.3 Localized Extinguishing Systems.

6-5.4.3.1 Where units are not enclosed and a first level of protection is desired that will operate before sprinklers, or where sprinklers are not installed, a localized extinguishing system might be appropriate. Such a system should be of an approved local application type such as water mist, carbon dioxide, dry chemical, or other approved gaseous extinguishing system.

6-5.4.3.2 Discharge rates and duration of discharge should be such that cooling and shutdown occurs to prevent reignition of the fire. System operation should be arranged to close fuel valves.

6-5.4.3.3 The positioning of local application nozzles should be such that maintenance access to the turbine or engine is maintained.

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

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 Generators.

6-5.6.1 Hydrogen systems should comply with recommendations in 5-7.1 and 5-7.4.4.

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 should be positive, such as by a gasket or grouting, all around the generator housing.

NOTE: The type of generator used with diesel engines is normally provided with an open drip proof enclosure. Shielding might be appropriate with water system, i.e., sprinklers or deluge.

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

NOTE: Large diesels are started with compressed air from an air receiver and do not require starting the engine.

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 9. The recommendations contained in Chapters 2 through 5 and Chapter 9 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 fireproofing 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 7-3.5*) 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, *Standard for the Installation of Standpipe and Hose Systems*, 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^2 (10.19 L/min-m^2) 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^2 (10.19 L/min-m^2) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft^2 (120 m^2). High temperature sprinklers [250°F to 300°F (121°C to 149°C)] should be used.

NOTE: The above requirements are based on storage heights not exceeding 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^2 (8.15 L/min-m^2) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of pit/floor area with the protection area per sprinkler not to exceed 100 ft^2 (9.3 m^2). High temperature sprinklers [250°F to 300°F (121°C to 149°C)] should be used. Exposed steel column protection, where provided, should be designed in accordance with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 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 kPa) 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 refuse derived fuels (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, acetelyne, explosives, etc. In the event of unsuitable material entering the processing stream, severe explosion and fire could result in the shredders or flailmills.

(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 and 3-1.1.3, 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 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 7-4.5.

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, *Standard for the Installation of Standpipe and Hose Systems*, 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.

7-4.4.4 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 permitted to be provided through operator action in accordance with operating procedures.

7-4.4.5 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^2 (10.19 L/min-m^2) 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.

7-4.4.6 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^2 (10.19 L/min-m^2) should be provided.

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

7-4.4.7 The tipping/receiving building should be provided with automatic sprinkler protection throughout. Systems should be designed for a minimum of 0.25 gpm/ft^2 (10.19 L/min-m^2) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft^2 (12.0 m^2). High temperature sprinklers [250°F to 300°F (121°C to 149°C)] should be used.

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

7-4.4.8 The processing building should be provided with automatic sprinkler protection throughout. Systems should be designed for a minimum of 0.25 gpm/ft^2 (10.19 L/min-m^2) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft^2 (12.0 m^2).

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.

7-4.4.9 The RDF storage building should be provided with automatic sprinkler protection throughout. Systems should be designed for a minimum of 0.35 gpm/ft^2 (14.26 L/min-m^2) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 100 ft^2 (9.3 m^2). High temperature sprinklers [250°F to 300°F (121°C to 149°C)] should be used. Storage heights in excess of 20 ft (6.1 m) will require higher design densities.

7-4.4.10 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^2 (8.15 L/min-m^2) over the most remote 2000 ft^2 (185.8 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft^2 (12.0 m^2). Internal, as well as external, protection also should be considered depending upon specific equipment design, ceiling heights, and accessibility for manual fire fighting.

7-4.4.11 Shredder enclosures should be provided with automatic sprinkler or water spray protection. Systems should be designed for a minimum of 0.25 gpm/ft^2 (10.19 L/min-m^2) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 100 ft^2 (9.3 m^2). Water spray protection should also be provided within the shredder housings at intake and discharge chutes and within vent shafts.

7-4.4.12 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 should 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 This 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, where 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 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Products Facilities*

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

(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 3-1.1.3, it is recommended that, as a minimum, fire area boundaries be provided to separate:

(a) the receiving/storage area; and

(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 8502, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burners*; NFPA 8503, *Standard for Pulverized Fuel Systems*; NFPA 8504, *Standard on Atmospheric Fluidized-Bed Boiler Operation*; 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, *Standard for the Installation of Standpipe and Hose Systems*, 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) 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^2 (10.19 L/min-m^2) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft^2 (12.0 m^2).

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^2 (10.19 L/min-m^2) 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 Btu/lb; 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 8502, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boilers*; NFPA 8503, *Standard for Pulverized Fuel Systems*; NFPA 8504, *Standard on Atmospheric Fluidized-Bed Boiler Operation*; and NFPA 8505, *Recommended Practice for Stoker Operation*.

7-6.2.3* Where 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.

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 Explosions 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.

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, *Standard for the Installation of Standpipe and Hose Systems,* 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^2 (9.77 L/min-m^2) over the entire pit area with the protection area per nozzle not to exceed 100 ft^2 (9.3 m^2).

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 kPa) 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, *Standard for Storage of Rubber Tires*.

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^2 (12.22 L/min-m^2) over the most remote 2500 ft^2 (232 m^2).

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^2 (10.19 L/min-m^2) 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 High Voltage Direct Current (HVDC) Converter Stations

8-1 General. This chapter identifies the fire hazards of high voltage direct current (HVDC) converter stations and specifies recommended protection criteria.

8-2 Application of Chapters 2 through 5 and Chapter 9. The recommendations contained in Chapters 2 through 5 and Chapter 9 may apply to high voltage direct current converter stations. It is incumbent upon the Fire Risk Evaluation to determine which recommendations apply to any specific HVDC converter station. 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 HVDC converter stations.

8-3 HVDC Converter Stations.

8-3.1 General.

8-3.1.1 This section (Section 8-3) identifies fire hazards that are associated with the operation of high voltage direct current converter stations. Conditions that could cause a fire in high voltage converter equipment include:

(a) loose electrical connections;

(b) electrical insulation or resistance breakdowns;

(c) overheated components;

(d) water leakage or intrusion (cooling system malfunction, roof leak, etc.); or

(e) foreign objects (tools, metal scrap, rubbish, vermin, etc.).

8-3.1.2 The hazards that could present a fire risk at a HVDC converter station include:

(a) Converter valve assemblies;

(b) Converter transformers;

(c) Oil-filled wall bushings;

(d) Capacitors containing combustible dielectric fluid or polymers; or

(e) Station services and auxiliary high voltage equipment.

8-3.2 Plant Arrangement.

8-3.2.1 Each thyristor valve hall should be established as a separate fire area. Each valve hall should be separated from adjacent fire areas by fire area boundaries in accordance with 3-1.1.3. Unless consideration of the factors of 3-1.1.2 indicates otherwise, it is recommended that fire area boundaries be provided to separate the following:

(a) service building;

(b) main control room;

(c) valve electronics rooms;

(d) HVAC equipment rooms; and

(e) relay room, SCADA room, and remote terminal unit room (RTU).

NOTE: If the Relay, SCADA, or RTU equipment is located in the main control room, fire partition barriers are not required for this equipment.

8-3.2.2 Converter valves and associated support equipment should use noncombustible or limited combustible materials. Where noncombustible or limited combustible materials are not used, fire-retardant separation barriers should be installed between the following equipment areas:

(a) valve tier levels, by adding to the bottom tray on each level;

(b) valve modules, by adding to the side of each tray section; and

(c) grading capacitors, snubber circuits, and power supplies.

8-3.2.3 Smoke or heat vents should be considered in accordance with 3-4.1.

8-3.2.4 Heating, ventilating, and air-conditioning (HVAC) systems for the valve hall should be provided with fire/smoke dampers arranged to shut down to preclude the entry of smoke from sources outside of the valve hall structure. A separate dedicated HVAC system should serve each valve hall.

8-3.2.5 Outdoor converter transformers and oil-filled smoothing reactor(s) should be arranged in accordance with 3-1.3 and 3-5.6.

8-3.2.6 Drainage provisions should be provided for indoor and outdoor oil-filled wall bushings. Drainage should be arranged in accordance with Section 3-5. Indoor oil-filled wall bushings should be provided with means to prevent the spread of oil to adjacent equipment. Where the converter bushings penetrate the valve hall, provisions should be made to prevent the oil contents of the transformer from entering the valve hall.

8-3.2.7 Mercury arc converters should be arranged to minimize the effects of a hazardous material spill or airborne contamination from mercury that could impede fire fighting efforts and restoration activities.

8-3.3 Fire Prevention.

8-3.3.1 An emergency communication system should be provided throughout the station to expedite assistance in the event of fire.

8-3.3.2 A fire emergency plan should be implemented in accordance with Section 2-7.

8-3.3.3 A regular housekeeping program should be established to maintain combustible and other materials in designated storage areas. Periodic cleaning of the valve and the valve hall structure should be performed in accordance with the manufacturer's instructions for maintaining a clean equipment and building environment.

8-3.3.4 Operational experience has demonstrated that operators and other plant personnel have been key factors in the detection of fires and unsafe conditions. It is important that all personnel be properly trained to observe and react appropriately to any potential fire situation.

NOTE: Control room operator fire emergency training should include, but not be limited to, the following:

(a) station emergency grounding procedures;

(b) valve hall clearance procedures;

(c) electrical equipment isolation; and

(d) timely communication of all fire events to the responding fire brigade and the fire department.

8-3.4 Fire Protection.

8-3.4.1 Hose stations designed in accordance with NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, should be located throughout the converter station.

8-3.4.2 Oil-filled wall bushings should be protected with automatic fire suppression system(s). The fire suppression system design should ensure that the fire suppression agent does not affect the converter valve, the arrestors, or other energized electrical equipment.

8-3.4.3 Auxiliary equipment areas and other structures should be protected with automatic protection systems in accordance with Sections 5-8 and 5-9. Converter transformers should be protected in accordance with 5-8.7.

8-3.4.4 The valve hall should be provided with an early warning multi-stage fire detection air sampling system capable of detecting an incipient fire such as an overheated component. Consideration should also be given to providing a second reliable fire detection system such as ionization, photo-electric, projected beam, optical devices, or video cameras. The interlock of a multi-stage smoke sampling system or the redundant fire detection system should be considered to initiate a fast-switch-off or emergency-switch-off of the respective valve group.

8-3.4.5 For the protection of the converter equipment and the building, water-based or gaseous agent suppression systems should be considered. The type and design of the suppression systems should be reviewed in consultation with the valve manufacturer.

8-3.4.6 To mitigate the effects of electrical shock and thermal impact involving the converter equipment, manual fire-fighting equipment utilization and deployment training should be provided for the fire brigade and responding fire department personnel.

Chapter 9 Fire Protection for the Construction Site

9-1 Introduction.

9-1.1 Although many of the activities on electric generating plant and HVDC converter station 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 should include safety to life, potential for delays in construction schedules and plant startup, as well as protection of property.

9-1.2 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.

9-1.3 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.

9-2 Administration.

9-2.1 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.

9-2.2 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 followed and the owner's right to administration and enforcement should be established.

9-2.3 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.*)

9-2.4 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.

9-2.5 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 for Security Services 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 permitted to 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 permitted to be omitted after the first round indicated in (a) above.

9-2.6 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.

9-2.7 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.

9-2.8 Construction and installation of fire barriers and fire doors should be given priority in the construction schedule.

9-3 Site Clearing and Construction Equipment.

9-3.1 Site Clearing.

9-3.1.1 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.

9-3.1.2 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.

9-3.1.3 Fire tools and equipment should be used for fire emergencies only and should be distinctly marked.

9-3.1.4 Each site utility vehicle should be equipped with at least one fire-fighting tool, portable fire extinguisher, or backpack pump filled with 4 gal to 5 gal (15 L to 19 L) of water.

9-3.1.5 Cut trees, brush, and other combustible spoil should be disposed of promptly.

9-3.1.6 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 9-2.*)

9-3.1.7 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.

9-3.2 Construction Equipment. Construction equipment should meet the requirements of NFPA 512, *Standard for Truck Fire Protection.*

9-4 Construction Warehouses, Shops, and Offices.

9-4.1 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.

9-4.2 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.*)

9-4.3 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.

9-4.4 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.

9-4.4.1 Building construction materials should be noncombustible or limited combustible. (*See Chapter 3.*)

9-4.4.2 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.

9-4.4.3 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 should 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 factor to consider is that relatively minor fire damage to the fabric envelope may leave the contents exposed to the elements.

9-4.5 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 ft^2 (9.29 m^2) or where the occupancy presents a fire exposure, the enclosure should be protected with an approved automatic fire extinguishing system.

9-4.6 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.

9-4.7 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.

9-4.8 Fire alarms should be connected to a constantly attended central location. All premise fire alarm systems should be installed, tested, and maintained as outlined in NFPA 72, *National Fire Alarm Code.*

9-4.9 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 at Farms and Isolated Sites.*

9-4.10 Vehicle repair facilities should meet the requirements of NFPA 88B, *Standard for Repair Garages.*

9-5 Construction Site Lay-Down Areas.

9-5.1 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.

9-5.2 Combustible materials should be separated by a clear space to allow access for manual fire-fighting equipment (*see Section 9-8*). Access should be provided and maintained to all fire-fighting equipment including fire hoses, extinguishers, and hydrants.

9-6 Temporary Construction Materials.

9-6.1 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.

9-6.1.1 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.

9-6.1.2 The use of listed pressure-impregnated fire-retardant lumber or listed fire-retardant coatings generally would be acceptable. Pressure-impregnated fire-retardant lumber should 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 should be suitable for this exposure. Fire-retardant coatings are not acceptable on walking surfaces or surfaces subject to mechanical damage.

9-6.2 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.*)

9-7 Underground Mains, Hydrants, and Water Supplies.

9-7.1 General.

9-7.1.1 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.

9-7.1.2 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.

9-7.2 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.

9-7.3 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-hour 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.

9-7.3.1 The highest water demand should be determined by the hazards present at the stage of construction, which might not correspond with the highest water demand of the completed plant.

9-7.3.2 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.

9-7.3.3 The water supply should be sufficient to provide adequate pressure for hose connections at the highest elevation.

9-8 Manual Fire Fighting Equipment.

9-8.1 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.

9-8.2 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.

9-8.3 Hoses and nozzles should be available at strategic locations, such as inside hose cabinets or hose houses or on dedicated fire response vehicles.

9-8.4 If fire hose connections are not compatible with local fire-fighting equipment, adapters should be made available.

Chapter 10 Referenced Publications

10-1 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.

10-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1994 edition.

NFPA 11, *Standard for Low-Expansion Foam*, 1994 edition.

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, 1994 edition.

NFPA 11C, *Standard for Mobile Foam Apparatus*, 1995 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 1993 edition.

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

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1994 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 1996 edition.

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

NFPA 16, *Standard for the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*, 1995 edition.

NFPA 16A, *Standard for the Installation of Closed-Head Foam-Water Sprinkler Systems*, 1994 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 1994 edition.

NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, 1993 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 1996 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 1995 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 1993 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*, 1994 edition.

NFPA 46, *Recommended Safe Practice for Storage of Forest Products*, 1996 edition.

NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, 1994 edition.

NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites*, 1994 edition.

NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*, 1994 edition.

NFPA 54, *National Fuel Gas Code*, 1992 edition.

NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, 1995 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Products Facilities*, 1995 edition.

NFPA 68, *Guide for Venting of Deflagrations*, 1994 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 1992 edition.

NFPA 70, *National Electrical Code*, 1996 edition.

NFPA 72, *National Fire Alarm Code*, 1993 edition.

NFPA 75, *Standard for the Protection of Electronic Computer/Data Processing Equipment*, 1995 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 1993 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1995 edition.

NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, 1993 edition.

NFPA 88B, *Standard for Repair Garages*, 1991 edition.

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, 1993 edition.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air Conditioning Systems*, 1993 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*, 1995 edition.

NFPA 92A, *Recommended Practice for Smoke-Control Systems*, 1993 edition.

NFPA *101*, *Life Safety Code*, 1994 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*, 1995 edition.

NFPA 231, *Standard for General Storage*, 1995 edition.

NFPA 231C, *Standard for Rack Storage of Materials*, 1995 edition.

NFPA 231D, *Standard for Storage of Rubber Tires*, 1994 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*, 1993 edition.

NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*, 1995 edition.

NFPA 252, *Standard Methods of Fire Tests of Door Assemblies*, 1995 edition.

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*, 1995 edition.

NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, 1996 edition.

NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*, 1993 edition.

NFPA 257, *Standard on Fire Test for Window and Glass Block Assemblies*, 1996 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 1993 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 at Farms and Isolated Sites*, 1993 edition.

NFPA 512, *Standard for Truck Fire Protection*, 1994 edition.

NFPA 600, *Standard on Industrial Fire Brigades*, 1996 edition.

NFPA 601, *Standard for Security Services in Fire Loss Prevention*, 1996 edition.

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, 1993 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films*, 1996 edition.

NFPA 704, *Standard System for the Identification of the Fire Hazards of Materials*, 1990 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 1995 edition.

NFPA 803, *Standard for Fire Protection for Light Water Nuclear Power Plants*, 1993 edition.

NFPA 851, *Recommended Practice for Fire Protection for Hydroelectric Generating Plants*, 1996 edition.

NFPA 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems*, 1994 edition.

NFPA 1962, *Standard for the Care, Use, and Service Testing of Fire Hose Including Couplings and Nozzles*, 1993 edition.

NFPA 1972, *Standard on Helmets for Structural Fire Fighting*, 1992 edition.

NFPA 8501, *Standard for Single Burner Boiler Operation*, 1992 edition.

NFPA 8502, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boilers*, 1995 edition.

NFPA 8503, *Standard for Pulverized Fuel Systems*, 1992 edition.

NFPA 8504, *Standard on Atmospheric Fluidized-Bed Boiler Operation*, 1993 edition.

NFPA 8505, *Recommended Practice for Stoker Operation*, 1992 edition.

10-1.2 Other Publications.

10-1.2.1 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 A1264.1, *Safety Requirements for Workplace Floor and Well Openings, Stairs, and Railing Systems.*

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*, 1993.

10-1.2.2 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19105.

ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 1994.

ASTM E 380 (*see ANSI Z210.1*), 1993.

ASTM E 814, *Fire Tests of Through-Penetration Fire Stops*, 1994.

10-1.2.3 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*, 1974.

IEEE 484, *Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations*, 1987.

IEEE 634, *Testing of Fire Rated Penetration Seals*, 1978.

IEEE 979, *Guide for Substation Fire Protection*, 1994.

10-1.2.4 OSHA Publication. Occupational Safety and Health Administration, Washington, DC.

29 CFR 1910.156, Fire Brigades, 1986.

10-1.2.5 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.

10-1.2.6 UL Publication. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 900, *Standard for Safety Test Performance of Air Filters*, 1987.

10-2 Related Publications.

10-2.1 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.