NFPA 850

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

2005 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
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 NFPA at its November Association Technical Meeting held November 13–17, 2004, in Miami Beach, FL. It was issued by the Standards Council on January 14, 2005, with an effective date of February 7, 2005, and supersedes all previous editions.

This edition of NFPA 850 was approved as an American National Standard on February 7, 2005.

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.

The 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.

The 2000 edition revised the application of the document to apply to existing facilities, as it is a good industry practice. Chapter 2 was reorganized to be specific to a fire risk control program. The document also clarified that a single water tank is not a reliable water supply, the spacing of hydrants, and lock-out of five suppression systems, and additional requirements were added for water mist fire suppression systems.

The 2005 edition of NFPA 850 has undergone a complete revision to comply with the *Manual of Style for NFPA Technical Committee Documents*. Chapter 2 now contains mandatory references and Chapter 3 now contains definitions, and the subsequent chapters have been renumbered.

Additional changes include revised figures in Chapter 5 that are intended to further clarify existing requirements and the addition of new annex material on fire protection requirements.

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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.

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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 Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in the recommendations sections of this document are given in Chapter 2 and those for extracts in the informational sections are given in Annex E. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text should be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex E.

Chapter 1 Administration

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 805, *Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants*; and hydroelectric plants are addressed in NFPA 851, *Recommended Practice for Fire Protection for Hydroelectric Generating Plants.*

1.2 Purpose.

1.2.1 This document is prepared for the guidance of those charged with the design, construction, operation, and protection of fossil fueled (i.e., coal, gas, or oil) or alternative fueled (i.e., municipal solid waste, refuse derived fuel, biomass, rubber tires, and other combustibles) steam electric generating plants, combustion turbine and internal combustion engine electric generating plants, and high voltage direct current converter stations.

1.2.2 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.

1.2.3 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, as the application to existing installations might not be practicable. However, the recommendations contained in this document represent good industry practice and should be considered for existing installations.

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 might require modification after due consideration of all local factors involved.

1.4 Equivalency. The provisions of this recommended practice reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this recommended practice at the time the recommended practice was issued.

1.4.1 Unless otherwise specified, the provisions of this recommended practice should not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the recommended practice. Where specified, the provisions of this recommended practice should be retroactive.

1.4.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction should be permitted to apply retroactively any portions of this recommended practice deemed appropriate.

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 SI 10, *Standard for Use of the International System of Units (SI): The Modern Metric System.*

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this recommended practice and should be considered part of the recommendations of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2002 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2005 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 2005 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems,* 2004 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2002 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2003 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2001 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems,* 2003 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems,* 2002 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2003 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2003 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 2002 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2002 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2003 edition.

NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages,* 2003 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 2001 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines,* 2002 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* 2003 edition.

NFPA 54, *National Fuel Gas Code,* 2002 edition.

NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks,* 2005 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 2004 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities,* 2002 edition.

NFPA 68, *Guide for Venting of Deflagrations,* 2002 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 2002 edition.

NFPA 70, *National Electrical Code®*, 2005 edition.

NFPA 72®, *National Fire Alarm Code®*, 2002 edition.

NFPA 75, *Standard for the Protection of Information Technology Equipment,* 2003 edition.

NFPA 77, *Recommended Practice on Static Electricity,* 2000 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows,* 1999 edition.

NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures,* 2001 edition.

NFPA 85, *Boiler and Combustion Systems Hazards Code,* 2004 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* 2002 edition.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems,* 2002 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* 2004 edition.

NFPA 92A, *Recommended Practice for Smoke-Control Systems,* 2000 edition.

NFPA *101®*, *Life Safety Code®*, 2003 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems,* 2005 edition.

NFPA 204, *Standard for Smoke and Heat Venting,* 2002 edition.

NFPA 214, *Standard on Water-Cooling Towers,* 2005 edition.

NFPA 220, *Standard on Types of Building Construction,* 1999 edition.

NFPA 230, *Standard for the Fire Protection of Storage,* 2003 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations,* 2004 edition.

NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials,* 1999 edition.

NFPA 252, *Standard Methods of Fire Tests of Door Assemblies,* 2003 edition.

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source,* 2000 edition.

NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials,* 2000 edition.

NFPA 256, *Standard Methods of Fire Tests of Roof Coverings,* 2003 edition.

NFPA 257, *Standard on Fire Test for Window and Glass Block Assemblies,* 2000 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials,* 2003 edition.

NFPA 600, *Standard on Industrial Fire Brigades,* 2005 edition.

NFPA 601, *Standard for Security Services in Fire Loss Prevention,* 2005 edition.

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities,* 2002 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films,* 2004 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response,* 2001 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems,* 2003 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems,* 2004 edition.

NFPA 805, *Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants,* 2001 edition.

NFPA 851, *Recommended Practice for Fire Protection for Hydroelectric Generating Plants,* 2005 edition.

NFPA 1143, *Standard for Wildland Fire Management,* 2003 edition.

NFPA 1144, *Standard for Protection of Life and Property from Wildfire,* 2002 edition.

NFPA 1221, *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems,* 2002 edition.

NFPA 1962, *Standard for the Inspection, Care, and Use of Fire Hose, Couplings, and Nozzles and the Service Testing of Fire Hose,* 2003 edition.

NFPA 1971, *Standard on Protective Ensemble for Structural Fire Fighting,* 2000 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems,* 2004 edition.

2.3 Other Publications.

2.3.1 ANSI Publication. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI C2, *National Electrical Safety Code*, 1981.

2.3.2 ASME Publication. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME B31.1, *Power Piping*, 1998.

2.3.3 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup*, 2003.

ASTM D 448, *Standard Classification for Sizes of Aggregate for Road and Bridge Construction*, 2003.

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

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

ASTM SI 10, *Standard for Use of the International System of Units (SI): the Modern Metric System*, 1997.

2.3.4 IEEE Publications. Institute of Electrical and Electronics Engineers, Three Park Avenue, 17th Floor, New York, NY 10016-5997.

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.

2.3.5 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 900, *Standard for Safety Test Performance of Air Filters,* 1995.

UL 1479, *Standard for Fire Tests of Through-Penetration Firestops,* 2003.

2.3.6 U.S. Government Publication. U.S. Government Printing Office, Washington, DC 20402.

Title 29, Code of Federal Regulations, Part 1910.156, "Fire Brigades," 1986.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter apply to the terms used in this recommended practice. Where terms are not defined in this chapter or within another chapter, they should be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary,* 11th edition, is the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 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.

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

3.2.5 Recommended Practice. A document that is similar in content and structure to a code or standard but that contains only nonmandatory provisions using the word "should" to indicate recommendations in the body of the text.

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

3.3 General Definitions.

3.3.1 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 fossil fuels (gas, oil, or coal) in a boiler to produce steam for the generation of electrical energy.

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

3.3.3 Combustible Material. A material that, in the form in which it is used and under the conditions anticipated, will ignite and burn; a material that does not meet the definition of noncombustible or limited-combustible.

3.3.4 Fire Barrier. A continuous membrane or a membrane with discontinuities created by protected openings with a specified fire protection rating, where such membrane is designed and constructed with a specified fire resistance rating to limit the spread of fire, that also restricts the movement of smoke. [***101,*** 2003]

3.3.5 Fire Loading. The amount of combustibles present in a given area, expressed in Btu/ft^2 (kJ/m^2). [**851,** 2005]

3.3.6 Fire Point. The lowest temperature at which a liquid will ignite and achieve sustained burning when exposed to a test flame in accordance with ASTM D 92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup.* [**30,** 2003]

3.3.7 Fire Prevention. Measures directed toward avoiding the inception of fire. [**801,** 2003]

3.3.8 Fire Protection. Methods of providing for fire control or fire extinguishment. [**801,** 2003]

3.3.9 Fire Rated Penetration Seal. An opening in a fire barrier for the passage of pipe, cable, duct, and so forth, that has been sealed so as to maintain a barrier rating. [**851,** 2005]

3.3.10 Fluid.

3.3.10.1 *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.

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

3.3.11 Fossil Fueled. Fuel containing chemical energy, which has been formed from animal and plant matter over many years (i.e., oil, coal, and natural gas) that are used in a boiler to produce steam for the generation of electrical energy.

3.3.12 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.

3.3.13 Interior Finish. The exposed surfaces of walls, ceilings, and floors within buildings. [***5000,*** 2003]

3.3.13.1 ***Class A Interior Finish.*** Materials having flame spread index 0–25, smoke developed index 0–450 when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*. Includes any material with a flame spread index of 25 or less and with a smoke developed index of 450 or less when any element thereof, when tested, does not continue to propagate fire.

3.3.13.2 ***Class B Interior Finish.*** Materials having flame spread index 26–75, smoke developed index 0–450 when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*. Includes any material with a flame spread index of –25 or more but not more than 75 and with a smoke developed index of 450 or less.

3.3.14 Limited Combustible. A building construction 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 8141 kJ/kg (3500 Btu/lb), where tested in accordance with NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, and complies with (a) or (b): (a) materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 3.2 mm (0.127 in.) that has a flame spread index not greater than 50; and (b) materials, in the form and thickness used, other than as described in (a), having neither a flame spread index greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion. (Materials subject to increase in combustibility or flame spread index beyond the limits herein established through the effects of age, moisture, or other atmospheric condition shall be considered combustible.)

3.3.15 Liquid.

3.3.15.1 ***Combustible Liquid.*** Any liquid that has a closed-cup flash point at or above 37.8°C (100°F). *(See NFPA 30, Flammable and Combustible Liquids Code.)*

3.3.15.2 ***Flammable Liquid.*** A liquid that has a closed-cup flash point that is below 37.8°C (100°F) and a maximum vapor pressure of 2068 mm Hg (40 psia) at 37.8°C (100°F).

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

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

3.3.16 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.

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

3.3.18 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 noncombustible.

3.3.19 Rating.

3.3.19.1 ***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 for Window and Glass Block Assemblies*, as applicable.

3.3.19.2 ***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.* [**220,** 1999]

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

Chapter 4 Fire Risk Control Program

4.1 General.

4.1.1 This chapter provides recommended criteria for the development of a fire risk control program that contains 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.

4.1.2 The fire risk control program recommended in this chapter should be reviewed and updated periodically.

4.1.3 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.

4.2 Management Policy and Direction.

4.2.1 Corporate management should establish a policy and institute a comprehensive fire risk control program to promote the conservation of property, continuity of operations, and protection of safety to life by adequate fire prevention and fire protection measures at each facility.

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

4.3 Fire Risk Control Program. A written plant fire prevention program should be established and as a minimum should include the following:

(1) 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.
(2) Documented regularly scheduled plant inspections including provisions for handling of remedial actions to correct conditions that increase fire hazards.
(3) 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.

(4) Control of flammable and combustible liquids and gases in accordance with appropriate NFPA standards.
(5) Control of ignition sources including smoking, grinding, welding, and cutting. *(See NFPA 51B, Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.)*
(6) Fire prevention surveillance. *(See NFPA 601, Standard for Security Services in Fire Loss Prevention.)*
(7) Fire report, including an investigation and a statement on the corrective action to be taken. *(See Annex B.)*
(8) Fire hazards of materials located in the plant or storage areas identified in accordance with NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.

4.4 Fire Protection Program.

4.4.1 Testing, Inspection, and Maintenance.

4.4.1.1 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.

4.4.1.2* All fire protection systems and equipment should be periodically inspected, tested, and maintained in accordance with applicable *National Fire Codes*. *(See Table 4.4.1.2 for guidance.)*

Table 4.4.1.2 Reference Guide for Fire Equipment Inspection, Testing, and Maintenance

Item	NFPA Document 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	25/72
Foam systems	11/16/25
Halogenated agent, chemical and CO_2 systems	12/12A/17/2001
Fire pumps and booster pumps	25/72
Water tanks and alarms	25/72
P.I.V.s and O.S. & Y. valves	25/72
Fire hydrants and associated valves	13/24
Fire hose and standpipes and hose nozzles	1962/25
Portable fire extinguishers	10
Fire brigade equipment	1971
Fire doors and dampers	80/90A
Smoke vents	204
Emergency lighting	110
Radio communication equipment	1221
Audible and visual signals	72
Water mist fire protection systems	750

4.4.1.3 Testing, inspection, and maintenance should be documented with written procedures, results, and follow-up corrective actions recorded and tracked for closure.

4.4.2 Impairments.

4.4.2.1 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). As a minimum this procedure should address the following:

(1) Identify equipment not available for service
(2) Identify personnel to be notified (e.g., plant fire brigade leader, public fire department, plant fire protection coordinator, control room operator)
(3) Increase fire surveillance as needed *[see Section 4.3(6)]*
(4) Provide additional protected measures as necessary (e.g., temporary water supplies, additional hose)

4.4.2.2 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.

4.4.2.3 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).

4.4.3 Management of Change. A system should be implemented that would ensure that the appropriate individual(s) with fire protection responsibility are made aware of new constructions, modifications to existing structures, changes to operating conditions, or other action that could impact the fire protection of the plant. The fire risk evaluation and the appropriate procedures and programs discussed in this chapter might need to be revised to reflect the impact of this action.

4.4.4* Fire Emergency Plan. A written fire emergency plan should be developed, and, as a minimum, this plan should include the following:

(1) Response to fire alarms and fire systems supervisory alarms
(2) Notification of personnel identified in the plan
(3) Evacuation of employees not directly involved in firefighting activities from the fire area
(4) Coordination with security forces or other designated personnel to admit public fire department and control traffic and personnel
(5) Fire preplanning that defines fire extinguishment activities
(6) Periodic drills to verify viability of the plan
(7) Control room operator(s) and auxiliary operator(s) activities during fire emergencies

4.4.5 Fire Brigade.

4.4.5.1 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. NFPA 600, *Standard on Industrial Fire Brigades* and OSHA standard 29 CFR 1910.156, "Fire Brigades," should be consulted for determining operation limitations.

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

4.4.6 Turbine Lubricating Oil Fires.

4.4.6.1 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 can be useful in minimizing fire damage and should be considered during preplanning and training for emergency conditions:

(1) Tripping the turbine
(2) Breaking condenser vacuum
(3) Emergency purging of the generator
(4) Shut down oil pumps

4.4.6.2 Shutting down oil pumps can cause additional mechanical damage to the turbine depending on rotating speed. However, it can be effective in mitigating the overall damage due to fire. *(See Annex D.)*

4.4.7 Special Fire-Fighting Conditions. Subsection 4.4.7 discusses special fire-fighting conditions unique to fossil fueled steam electric generating plants. This information might be useful in fire preplanning. It could also be utilized in the education and training of both on-site and off-site fire-fighting personnel who would respond in the event of a fire emergency.

4.4.7.1 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.

4.4.7.2 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 can be permitted to be opened and water hoses employed if necessary.

4.4.7.3 Cable Trays. Cable tray fires should be handled like any fire involving energized electrical equipment. It might not be practical or desirable to de-energize 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.

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

4.4.7.5 Coal Storage and Handling.

4.4.7.5.1 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.

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

4.4.7.6 Coal Pulverizers. *(See NFPA 85, Boiler and Combustion Systems Hazards Code.)*

4.5 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 Hazards of Materials for Emergency Response.*

Chapter 5 General Plant Design

5.1 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. The fire risk evaluation should be approved by the owner prior to final drawings and installation.

5.2 Plant Arrangement.

5.2.1 Fire Area Determination.

5.2.1.1 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.

5.2.1.2 Determination of fire area boundaries should be based on consideration of the following:

(1) Types, quantity, density, and locations of combustible material
(2) Location and configuration of plant equipment
(3) Consequence of losing plant equipment
(4) Location of fire detection and suppression systems

5.2.1.3* Unless consideration of the factors of 5.2.1.2 indicates otherwise or if adequate spatial separation is provided as permitted in 5.2.1.5, it is recommended that fire area boundaries be provided to separate the following:

(1) Cable spreading room(s) and cable tunnel(s) from adjacent areas
(2) Control room, computer room, or combined control/computer room from adjacent areas
(3) Rooms with major concentrations of electrical equipment, such as switchgear room and relay room, from adjacent areas
(4) Battery rooms from adjacent areas
(5) Maintenance shop(s) from adjacent areas
(6) Main fire pump(s) from reserve fire pump(s) where these pumps provide the only source of fire protection water
(7) Fire pumps from adjacent areas

(8) Warehouses from adjacent areas
(9) Emergency internal combustion generators from each other and from adjacent areas
(10) Fossil fuel–fired auxiliary boiler(s) from adjacent areas
(11) Fuel oil pumping, fuel oil heating facilities, or both, used for continuous firing of the boiler from adjacent areas
(12) Storage areas for flammable and combustible liquid tanks and containers from adjacent areas
(13) Office buildings from adjacent areas
(14) Telecommunication rooms from adjacent areas
(15) Adjacent turbine generators beneath the underside of the operating floor

5.2.1.4 Fire barriers separating fire areas should be a minimum of 2-hour fire resistance rating.

5.2.1.5 If a fire area is defined as a detached structure, it should be separated from other structures by an appropriate distance as determined by NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, evaluation.

5.2.2 Openings in Fire Barriers.

5.2.2.1* All openings in fire barriers should be provided with fire door assemblies, fire dampers, through 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. Through penetration fire stops 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,* or ANSI/UL 1479, *Standard for Fire Tests of Through-Penetration Firestops,* are permitted to be considered for this application.

5.2.2.2 Fire door assemblies, fire dampers, and fire shutters used in 2-hour–rated fire barriers should be listed and approved for a minimum 1½ hour fire rating. *(See NFPA 80, Standard for Fire Doors and Fire Windows.)*

5.2.3 Hydrogen Storage. Hydrogen storage facilities should be separated from adjacent areas. *(See NFPA 55, Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks.)*

5.2.4 Outdoor Oil-Insulated Transformers.

5.2.4.1 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.

5.2.4.2 Determination of the type of physical separation to be used should be based on consideration of the following:

(1) Type and quantity of oil in the transformer
(2) Size of a postulated oil spill (surface area and depth)
(3) Type of construction of adjacent structures
(4) Power rating of the transformer
(5) Fire suppression systems provided
(6) Type of electrical protective relaying provided

5.2.4.3* Unless consideration of the factors in 5.2.4.2 indicates otherwise, it is recommended that any oil-insulated transformer containing 500 gal (1890 L) or more of oil be separated from adjacent noncombustible or limited combustible structures by a 2-hour–rated firewall or by spatial separation in accordance with Table 5.2.4.3. Where a firewall is provided between structures and a transformer, it should extend vertically and horizontally as indicated in Figure 5.2.4.3.

Table 5.2.4.3 Outdoor Oil-Insulated Transformer Separation Criteria

Transformer Oil Capacity		Minimum (Line-of-Sight) Separation Without Firewall	
gal	L	ft	m
<500	<1,890	See 5.2.4.2	
500–5000	1,890–18,925	25	7.6
>5000	>18,925	50	15

5.2.4.4 Unless consideration of the factors in 5.2.4.2 indicates otherwise, it is recommended that adjacent oil-insulated transformers containing 500 gal (1890 L) or more of oil be separated from each other by a 2-hour–rated firewall or by spatial separation in accordance with Table 5.2.4.3. 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. *(See Figure 5.2.4.4 for an illustration of the recommended dimensions for a firewall.)*

5.2.4.5* Where a firewall is provided, it should be designed to withstand the effects of projectiles from exploding transformer bushings or lightning arresters.

5.2.4.6 For transformers with less than 500 gal (1890 L) of oil and 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.

5.2.4.7 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 5.2.4.2 and 5.2.4.5.

5.2.5 Indoor Transformers.

5.2.5.1 Dry-type transformers are preferred for indoor installations.

5.2.5.2* 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-hour fire resistance rating.

5.2.5.3 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-hour fire resistance rating.

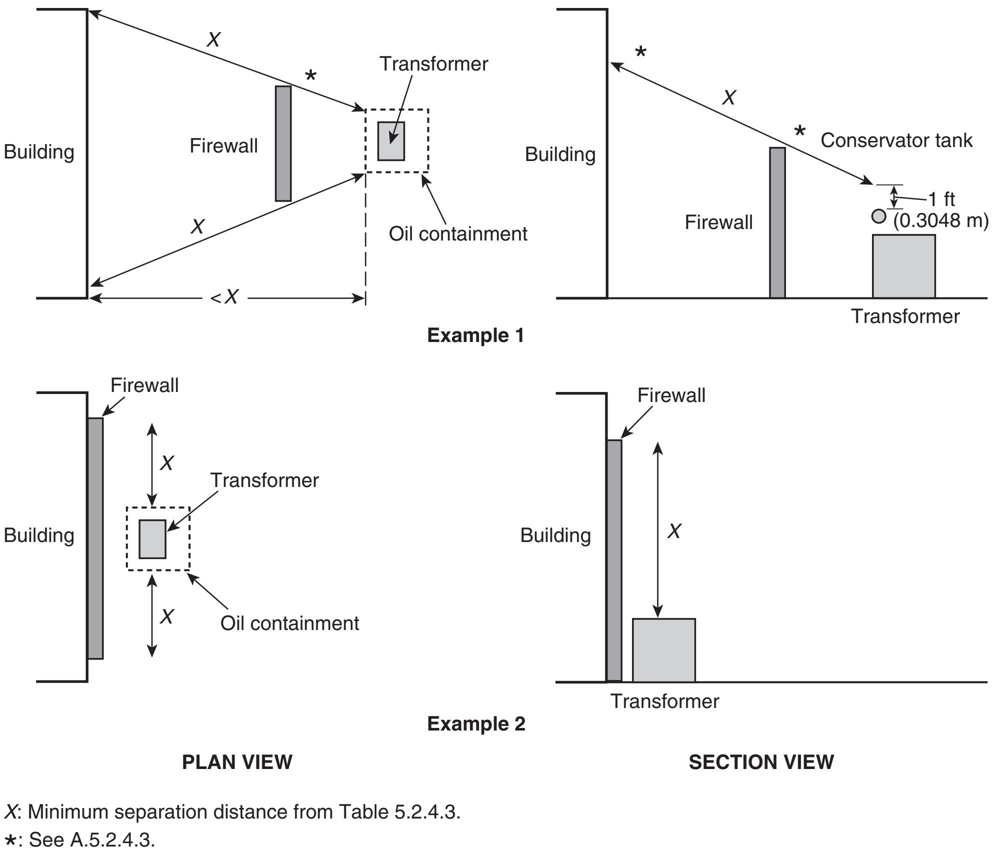

FIGURE 5.2.4.3 Illustration of Oil-Insulated Transformer Separation Recommendations.

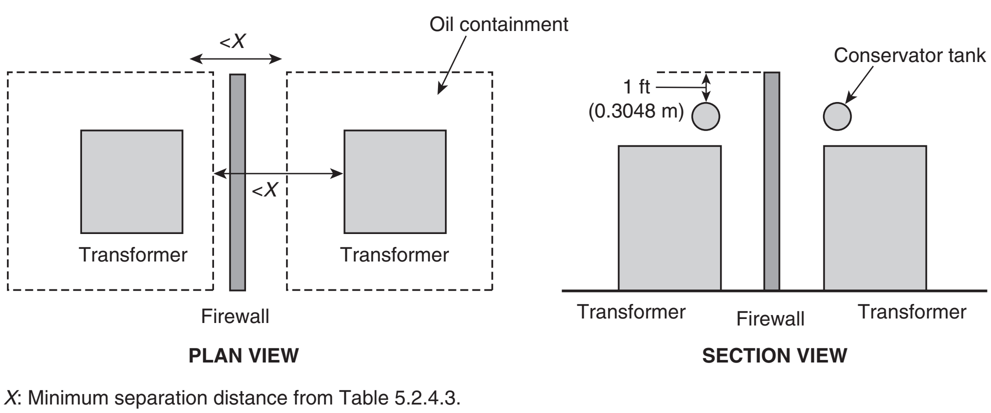

FIGURE 5.2.4.4 Outdoor Oil-Insulated Transformer Separation Criteria.

5.2.5.4 Where transformers are protected by an automatic fire suppression system, the fire barrier fire resistance rating is permitted to be reduced to 1 hour.

5.3 Life Safety.

5.3.1 For life safety for electric generating plants included in the scope of this document, see NFPA *101*, *Life Safety Code*.

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

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

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

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

(4) Warehouses should be considered as storage occupancies.

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

5.3.3 In the event of a plant fire, egress of occupants in control facilities can be delayed due to emergency shutdown procedures. *(See NFPA 101, Life Safety Code, 40.2.5.1.2, Ancillary Facilities with Delayed Evacuation.)* Control facilities should have a means of egress that is separated from other plant areas to facilitate a delayed egress.

5.4 Building Construction Materials.

5.4.1 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:

(1) NFPA 220, *Standard on Types of Building Construction*
(2) NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*
(3) NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*
(4) NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*
(5) NFPA 259, *Standard Test Method for Potential Heat of Building Materials*

5.4.2 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 5.4.3, and except for limited use of translucent reinforced plastic panels as allowed by the fire risk evaluation.

5.4.3 The use of material that does not meet the definition of *noncombustible* or *limited combustible*, such as translucent reinforced plastic panels, are permitted in limited applications if the fire risk evaluation demonstrates they are acceptable.

5.4.4 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."

5.4.5 Interior Finish.

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

5.4.5.2 Interior finish in buildings critical to power generation or conversion should be Class A.

5.4.5.3 Interior finish in buildings not critical to power generation or conversion should be Class A or Class B.

5.5 Smoke and Heat Venting, Heating, Ventilating, and Air Conditioning.

5.5.1 Smoke and Heat Venting.

5.5.1.1 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. Smoke and heat vents should be included in preventative maintenance or surveillance programs to ensure availability in emergency situations.

5.5.1.2 Heat Vents.

5.5.1.2.1 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.

5.5.1.2.2 Heat vents in the boiler and turbine building are 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 204, Standard for Smoke and Heat Venting.)*

5.5.1.3 Smoke Vents.

5.5.1.3.1 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.

5.5.1.3.2 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 204, Standard for Smoke and Heat Venting.)* Smoke venting also is permitted to be accomplished through the use of portable smoke ejectors.

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

5.5.1.3.4 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.

5.5.1.3.5 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 are permitted to be operable from the control room if provisions are made to prevent premature operation, which can be accomplished using thermal interlocks or administrative controls.

5.5.1.3.6 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.

5.5.2 Normal Heating, Ventilating, and Air-Conditioning Systems.

5.5.2.1 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.

5.5.2.2 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.

5.5.2.3 Plastic ducts, including listed fire-retardant types, should not be used for ventilating systems. Listed plastic fire-retardant ducts with appropriate fire protection are permitted to be used in areas with corrosive atmospheres.

5.5.2.4 Fire dampers (doors) compatible with the rating of the barrier should be provided at the duct penetrations in accordance with NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, to the fire area unless the duct is protected throughout its length by a fire barrier equal to the rating required of fire barrier(s) penetrated *(see Section 5.2)*.

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

5.5.2.6 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.

5.6 Drainage.

5.6.1 Provisions should be made in all fire areas of the plant for removal of liquids directly to safe areas or for containment in the fire area without flooding of equipment and without endangering other areas. *(See Annex 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:

(1) Floor drains
(2) Floor trenches
(3) Open doorways or other wall openings
(4) Curbs for containing or directing drainage
(5) Equipment pedestals
(6) Pits, sumps, and sump pumps

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

(1) The spill of the largest single container of any flammable or combustible liquids in the area
(2) The maximum expected number of fire hose operating for a minimum of 10 minutes
(3) The maximum design discharge of fixed fire suppression systems operating for a minimum of 10 minutes

5.6.3 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 can impinge on the boiler face.

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

5.6.5 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.

5.6.6 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 5.6.2. 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:

(1) Sizing of the pit should allow for the volume of the stone.
(2) The design should address the possible accumulation of sediment or fines in the stone.
(3) Overflow of the containment pit and/or curbing should be considered in reviewing drainage pathways away from critical structures. Common containment pits for multiple transformers should be avoided.

5.6.6.1 Rock-Filled Pits. Where rock-filled pits are used, the rock should periodically be loosened and turned as necessary to prevent filling of void spaces by dirt, dust, or silt. The frequency is dependent on area of the country and location near manufacturing facilities that generate dust or fly ash.

5.6.6.2 Open Pits. Where an open pit is used, one of the following forms of protection should be provided:

(1) Automatic sprinkler or water spray protection should be provided for the pit area designed to a discharge density of 0.15 gal/min·ft^2 (6 mm/min) over the area of the pit.
(2) A 12 in. (30 cm) thick layer of rock located between steel grating should be provided at the top of the pit. The rock used should be 1.5 in. (3.8 cm) or larger washed and uniformly sized rock (size No. 2, ASTM D 448 *Standard Classification for Sizes of Aggregate for Road and Bridge Construction*).

5.6.7 For facilities consisting of more than one generating unit that are not separated by a fire barrier *[see 5.2.1.3(15)]*, 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.

5.6.8 For environmental reasons, liquid discharges resulting from oil spills or operation of a fire suppression system might have to be treated (e.g., oil separation).

5.7 Emergency Lighting.

5.7.1 Emergency lighting should be provided for means of egress. *(See NFPA 101, Life Safety Code.)*

5.7.2 Emergency lighting should be provided for critical plant operations areas.

5.8 Lightning Protection. Lightning protection should be provided for those structures having a risk index (R) of 4 or greater when evaluated in accordance with NFPA 780, *Standard for the Installation of Lightning Protection Systems*.

Chapter 6 General Fire Protection Systems and Equipment

6.1 General. All fire protection systems, equipment, and installations should be dedicated to fire protection purposes.

6.2 Water Supply.

6.2.1 The water supply for the permanent fire protection installation should be based on providing a 2-hour supply for both 6.2.1(1) and 6.2.1(2) as follows:

(1) Either of the following, whichever is larger:
   (a) The largest fixed fire suppression system demand
   (b) 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 5.2.4]
(2) The hose stream demand of not less than 500 gpm (1890 L/min)

6.2.2 A reliable water supply should be provided at this facility. The fire risk evaluation should evaluate the need for multiple sources. Factors to consider should include the following:

(1) Reliability of source
(2) Capacity of source
(3) Reliance on water-based fire protection systems
(4) Availability of alternate and backup sources
(5) Consequences of loss

6.2.2.1 Potential sources to be considered can include tanks, ponds, rivers, municipal supplies, and cooling tower basins.

6.2.3 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.

6.2.4 In some rivers and tributaries the existence of microorganisms limits the use of raw water for fire protection without treatment. Consideration of water quality can prevent long-term problems relating to fire protection water supply. Demineralized water and ash water should not be considered for use as a fire protection water source due to excessive corrosion and erosion characteristics.

6.2.5 Fire Pumps.

6.2.5.1 Where multiple fire pumps are required by the fire risk evaluation, 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 6.2.1 with the largest pump out of service.

6.2.5.2 Fire pumps should be automatic starting with manual shutdown, except as allowed in NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.* The manual shutdown should be at the pump controllers only. *(See NFPA 20.)*

6.2.6 Water Supply Tanks.

6.2.6.1 If tanks are of dual-purpose use, a standpipe or similar arrangement should be provided to dedicate the amount determined by 6.2.1 for fire protection use only. *(See NFPA 22, Standard for Water Tanks for Private Fire Protection.)*

6.2.6.2 Where tanks are used, they should be filled from a source capable of replenishing the 2-hour supply for the fire protection requirement in an 8-hour period. The 8-hour (time) requirement for refilling can 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.

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

(1) Electrical supervision with audible and visual signals in the main control room or another constantly attended location.
(2) Locking valves open. Keys should be made available only to authorized personnel.
(3) Sealing valves open. This option should be followed only where valves are within fenced enclosures under the control of the property owners.

6.4 Yard Mains, Hydrants, and Building Standpipes.

6.4.1 Yard Mains and Hydrants.

6.4.1.1 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.)* Hydrant spacing in main plant areas should be a maximum of 300 ft (91.4 m). Hydrant spacing in remote areas such as long-term coal storage should be a maximum of 500 ft (152.4 m).

6.4.1.2 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 can 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.

6.4.1.3 The supply mains should be looped around the main power block and should be of sufficient size to supply the flow requirements determined by 6.2.1 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.

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

6.4.1.5 Each hydrant should be equipped with a separate shutoff valve located on the branch connection to the supply main.

6.4.1.6 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.

6.4.2 Standpipe and Hose Systems.

6.4.2.1 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.

6.4.2.2 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.)*

6.4.2.3 The standpipe piping should be capable of providing minimum volume and pressure for the highest hose stations.

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

6.4.3 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.

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

6.5 Portable Fire Extinguishers. Portable fire extinguishers should be provided. *(See NFPA 10, Standard for Portable Fire Extinguishers.)*

6.6 Fire Suppression Systems and Equipment — General Requirements.

6.6.1 Fire suppression systems and equipment should be provided in all areas of the plant as identified in Chapters 7, 8, 9, and 10 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-, Medium-, and High-Expansion Foam*
NFPA 12, *Standard on Carbon Dioxide 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 Foam-Water Sprinkler and Foam-Water Spray Systems*
NFPA 17, *Standard for Dry Chemical Extinguishing Systems*
NFPA 750, *Standard on Water Mist Fire Protection Systems*
NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*

6.6.2 The selection of an extinguishing agent or a combination of extinguishing agents should be based on the following:

(1) The type of hazard
(2) The effect of agent discharge on equipment
(3) The health hazards

6.6.3 Fire Suppression System Safety Considerations.

6.6.3.1 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.

6.6.3.2 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.

6.6.3.3 When working in areas (e.g., combustion turbine compartments) where actuation of the fire protection system could effect personnel safety, the fire extinguishing system should be locked out to prevent discharge of the system. A trouble indication should be provided when the system is locked out.

6.6.3.4 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.

6.7 Fire-Signaling Systems.

6.7.1 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*.

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

6.7.3 The fire-signaling system or plant communication system should provide the following:

(1) 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.
(2) 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.
(3) Two-way communications for the plant emergency organization during emergency operations.
(4) Means to notify the public fire department.

Chapter 7 Identification of and Protection Against Hazards

7.1 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.

7.1.1 Fire Protection Operation. With few exceptions, fire protection systems should be automatically actuated to ensure prompt operation. Manually activated systems may cause delays in response times unacceptable for most hazards.

7.2 Fuel Handling — Gas.

7.2.1 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, *Liquefied Petroleum Gas Code*; and ASME B31.1, *Power Piping*.

7.2.2 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.

7.2.3 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*.

7.3 Fuel Handling — Oil.

7.3.1 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 ASME B31.1, *Power Piping*.

7.3.2 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.

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

7.3.4 Tank filling operations should be monitored to prevent overfilling.

7.3.5 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.

7.3.6 Pump installations should not be located within tank dikes.

7.3.7 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*.

7.3.8 To prevent hazardous accumulations of flammable vapors, ventilation for indoor pumping facilities for flammable liquids or combustible liquids at or above their flash point should provide at least 1 cfm of exhaust air per ft^2 of floor area ($0.30\ m^3/min/m^2$), but not less than $150\ ft^3/min$ ($0.071\ m^3/sec$). Ventilation should be accomplished by mechanical or natural exhaust ventilation arranged in such a manner to include all floor areas or pits where flammable vapors can collect. Exhaust ventilation discharge should be to a safe location outside the building.

7.3.9 Fire Protection.

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

7.3.9.2 The provisions of foam systems for outdoor storage tank protection should be considered in the fire risk evaluation. The fire risk evaluation should regard exposure to other storage tanks and important structures, product value, and resupply capability, as well as the anticipated response and capabilities of the local fire brigade.

7.3.9.3 Outdoor fuel oil handling and storage areas should be provided with hydrant protection in accordance with Section 6.4.

7.4 Fuel Handling — Coal.

7.4.1 Storage.

7.4.1.1* 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.

7.4.1.2 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 the following:

(1) Short duration, active, or "live" storage piles should be worked to prevent dead pockets of coal, a potential source of spontaneous heating.
(2) Coal piles should not be located above sources of heat, such as steam lines, or sources of air, such as manholes.
(3) 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.
(4) Different types of coal that are not chemically compatible should not be stored in long-term storage piles.
(5) Access to coal storage piles should be provided for fire-fighting operations and for pulling out hot pockets of coal.

7.4.2 Bins, Bunkers, and Silos. The recommendations of 7.4.2 should be considered to reduce the probability of serious fire. *(See NFPA 85, Boiler and Combustion Systems Hazards Code.)*

7.4.2.1* Storage structures should be of noncombustible construction and designed to minimize corners, horizontal surfaces, or pockets that cause coal to remain trapped and present a potential for spontaneous combustion. Bins, bunkers, and silos should be designed with access ports to allow manual fire-fighting activities such as the use of a piercing rod hand line for delivery of micelle-encapsulating agents with water. Access ports should be provided around the bunker or silo to allow direct attack on the fire using the piercing rod. Silos greater than 50 ft (15.2 m) in height should be provided with access ports at multiple elevations.

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

7.4.2.3* 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.

7.4.2.4 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.

7.4.2.5 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 unloading process 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.

7.4.2.6* 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):

(1) Use of Class A foams and penetrants
(2) Injection of inert gas (i.e., carbon dioxide or nitrogen)
(3) Emptying the silo through the feeder pipe to a safe location (inside or outside the powerhouse) and trucking away the debris

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. However, use of micelle-encapsulating agents with water can be highly effective for coal fires, especially Powder River Basin (PRB) coal fires. This use of micelle-encapsulating agents typically results in significantly less water being delivered into the silo due to the enhanced fire suppression properties of the agent and subsequent shorter delivery period.
(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, which 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.

7.4.2.7 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.

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

7.4.3* Dust Suppression and Control.

7.4.3.1 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:

(1) A dust collection system
(2) A dust suppression system
(3) An open-air construction
(4) Passive design features of the conveyor chutes and dust hoods to minimize generation of dust and spillage of coal at the transfer points

7.4.3.2* 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.

7.4.3.3 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.

7.4.3.4 For dust collection systems provided for handling combustible dusts, see NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*. Other recommendations for reducing the probability of explosion and fire from coal dust are as follows:

(1) Fans for dust collectors should be installed downstream of the collectors so that they handle only clean air.
(2) For dust collectors vented to the outside, see NFPA 68, *Guide for Venting of Deflagrations*. Explosion suppression systems are permitted to be provided for dust collection systems that cannot be safely vented to the outside. *(See NFPA 69, Standard on Explosion Prevention Systems.)*
(3) 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.
(4) High level detection with an annunciator alarm should be provided for the dust hoppers.

7.4.3.5* 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.

7.4.4 Coal Conveyors.

7.4.4.1 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 might require additional fire protection.

7.4.4.2 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.

7.4.4.3 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.

7.4.4.4 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.

7.4.4.5 Prior to extended idle periods, the conveyor system should be cleared of coal.

7.4.5 Coal Conveying and Handling Structures.

7.4.5.1 Coal conveying and handling structures and supports should be of noncombustible construction.

7.4.5.2 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.

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

7.4.5.4 Provisions should be made for de-energizing both lighting and electrical power circuits without requiring personnel to enter dust-producing sections of the plant during emergencies.

7.4.5.5 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).

7.4.5.6 Electrical equipment within coal handling areas should be approved for use in hazardous locations Class II, Division 1 or Division 2, Group F. *(See Article 502 of NFPA 70, National Electrical Code.)* 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.)*

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

7.4.6 Fire Protection.

7.4.6.1 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 (10.2 mm/min) 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.

7.4.6.2* Automatic water spray or sprinkler systems should be provided for enclosed coal conveyors that are critical to continuous power generation. Coverage should be provided at transfer points (tail dust hoods and head chutes). Sprinklers should be designed for a minimum of 0.25 gpm/ft^2 (10.2 mm/min) 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.*

7.4.6.2.1* 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. The conveyor width and other sprinkler obstructions should be considered in protection of the return belt and other floor level equipment. See NFPA 13, *Standard for the Installation of Sprinkler Systems*, for positioning of sprinklers to avoid obstructions. Where sprinklers cannot provide adequate coverage due to obstructions, a water spray system using above and below belt nozzles should be considered instead of a sprinkler system.

7.4.6.2.2 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 might not be critical to plant operations.

7.4.6.2.3 Actuation of water spray or sprinkler systems should shut down the conveyor belt involved and all conveyor belts feeding the involved belt.

7.4.6.2.4 The sprinkler or water system control valve should be located in an area or enclosure separate from the hazard.

7.4.6.2.5 Dust collectors and fans should automatically shut down along with other related equipment upon detection of fire.

7.4.6.2.6 Draft barriers installed at the end and midpoints of enclosed conveyors and between separate sprinkler and water spray systems where the length of the conveyor requires multiple systems 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.

7.4.6.3 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 might 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.

7.4.6.4 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 pre-engineered fixed automatic gaseous-type suppression system activated by a fixed temperature detection system.

7.4.6.5 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.

7.4.6.5.1 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 (8.1 mm/min) over the projected plan area of the dust collector. Use of a micelle-encapsulating agent should be considered for PRB coal dust collectors.

7.4.6.5.2 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.

7.4.6.5.3 Consideration should be given to providing automatic sprinkler systems for bag-type dust collectors located outdoors that do the following:

(1) Are in continuous operation
(2) Process large amounts of coal dust
(3) Have limited access for manual fire fighting

7.4.6.5.3.1 An example of limited access would be collectors that have catwalks for access.

7.5 Steam Generator. For boiler-furnaces, see NFPA 85, *Boiler and Combustion Systems Hazards Code*.

7.5.1 Fire Protection.

7.5.1.1 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.

7.5.1.2 Boiler front fire protection systems should be designed to cover the fuel oil burners and ignitors and 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 can collect. Sprinkler and water spray systems should be designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over the protected area.

7.5.2 Pulverizers.

7.5.2.1 For pulverized fuel systems, see NFPA 85, *Boiler and Combustion Systems Hazards Code*.

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

7.5.3 Boiler Feed Pumps.

7.5.3.1 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 are 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, can require protection depending on the quantity of oil, oil pressure, or exposure to other equipment.

7.5.3.2 Hydraulic and lubricating oil hazards associated with boiler feed pumps that are driven with steam turbines should be protected in accordance with 7.7.4.1. The use of a listed fire-resistant lubricant and hydraulic fluid can eliminate the need for fire protection systems.

7.5.3.3 Curbing or drainage or both should be provided for the steam-driven boiler feed pump oil reservoirs in accordance with Section 5.6.

7.6 Flue Gas.

7.6.1 Forced Draft, Induced Draft, and Flue Gas Recirculation Fans.

7.6.1.1 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 can 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 (10.2 mm/min) over the oil containment equipment surface. Water spray systems should be designed for 0.25 gpm/ft^2 (10.2 mm/min) 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.

7.6.1.2 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 7.6.1.1.

7.6.2 Regenerative Air Heaters.

7.6.2.1 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.

7.6.2.2 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.

7.6.2.3* 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 might 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 can allow operators time to quickly detect a fire, isolate the air heater, open drains, and activate the water spray system.

7.6.2.4 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 can require more than one observation port. Observation ports should be placed such that they are accessible for viewing the rotor or stator surface.

7.6.2.5 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 (24.4 mm/min) 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 (12.2 mm/min) density is recommended on both sides. Water wash systems might not be adequate to give full coverage because of rotor drive failure.

7.6.2.6 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.

7.6.2.7 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.

7.6.2.8 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 stoppage 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 can result in a fire. Stoppage also can 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.

7.6.3 Flue Gas Bag–Type Dust Collectors.

7.6.3.1 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.

7.6.3.2 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.

7.6.3.3 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 (8.1 mm/min) over the plan area of the dust collector.

7.6.3.4 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.

7.6.3.5 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.

7.6.3.6 One of the following should be provided to prevent high temperature inlet flue gas from damaging the bags:

(1) Where permitted for emergency conditions, an automatic isolation valve and bypass duct to divert inlet gas streams around the flue gas bag collector
(2) A flue gas tempering water spray system in the duct between the boiler and the flue gas bag collector

7.6.3.7 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.

7.6.3.8 Access doors or hatches for manual fire fighting and viewing ports should be provided for all compartments.

7.6.4 Electrostatic Precipitators.

7.6.4.1 Electrostatic precipitators can be damaged by heat from a fire. High temperatures can warp collecting plates, decreasing collection efficiency. Combustibles can 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.

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

7.6.4.3 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:

(1) 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 (10.2 mm/min) over the exposed surface of the transformer-rectifier set. Automatic sprinkler systems should be designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) 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.
(2) Fire barrier(s) or spatial separation in accordance with Chapter 5. *(See 5.2.4 and 5.2.5.)*

7.6.5* Scrubbers and Exhaust Ducts.

7.6.5.1 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.

7.6.5.2 Scrubber Buildings.

7.6.5.2.1 Buildings should be constructed of materials meeting the criteria outlined in Section 5.4.

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

(1) Automatic sprinkler protection at ceiling level sized to provide 0.20 gpm/ft^2 (8.1 mm/min). 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.
(2) The roof deck and supporting steel should be protected with a 1-hour fireproof coating. Building columns should be protected with a 2-hour fireproof coating from the roof to 20 ft (6.1 m) below the roof. Columns adjacent to scrubber openings should be protected from the roof to below the scrubber opening. Automatic or remotely actuated heat venting should be provided with a vent area of 1 ft^2 (0.09 m^2) per 50 ft^2 (4.6 m^2) of floor area.

7.6.5.2.3 If a listed less flammable fluid is not used, hydraulic and lubricating oil equipment should be protected as described in 7.7.4.

7.6.5.3 Scrubbers.

7.6.5.3.1 Materials of Construction. Scrubbers, internal piping, and ducts should be constructed of noncombustible materials, or the recommendations of 7.6.5.3.2 and 7.6.5.3.3 should be incorporated.

7.6.5.3.2 During outages, all of the following should be done:

(1) 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.
(2) All equipment lined with combustible material should be identified with warning signs or placards.
(3) The scrubber reservoir should be maintained full if possible or returned to service as quickly as possible during an outage.
(4) 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.

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

(1) 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.
(2) 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.
(3) 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.
(4) Standpipes should be provided such that 1½ in. (3.8 cm) hose is available at scrubber access hatches that are open during outages.
(5) Combustible materials in the scrubber should be limited and controlled during maintenance and inspection outages.

7.6.5.4 Limestone Conveyors. Limestone conveyors for use with flue gas desulfurization systems should meet the fire protection requirements of 7.4.4.1, 7.4.4.2, 7.4.4.3, and 7.4.5.1. 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.

7.6.6 Stacks.

7.6.6.1 Noncombustible liners should be used where practical. *(See Annex C for fire tests.)*

7.6.6.2 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-hour fire barrier or a 1-hour fire barrier if automatic sprinkler protection is provided over the combustible material.

7.6.6.3 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.

7.6.6.4 Ignition sources should be eliminated when working inside plastic liners.

7.7 Turbine-Generator.

7.7.1 Hydrogen System.

7.7.1.1 General.

7.7.1.1.1 For hydrogen storage systems, see NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks.*

7.7.1.1.2 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 can be used in the building to protect runs of hydrogen piping.

7.7.1.1.3 Routing of hydrogen piping should avoid hazardous areas and areas containing critical equipment.

7.7.1.1.4 Hydrogen cylinders and generator hydrogen fill and purge manifold should be located remote from the turbine generator.

7.7.1.1.5 For electrical equipment in the vicinity of the hydrogen handling equipment, see Article 500 of NFPA 70, *National Electrical Code,* and Section 127 of ANSI C2, *National Electrical Safety Code.*

7.7.1.2 Hydrogen Seal Oil Pumps.

7.7.1.2.1 Redundant hydrogen seal oil pumps with separate power supplies should be provided for adequate reliability of seal oil supply.

7.7.1.2.2 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.

7.7.1.3 Curbing or drainage or both should be provided for the hydrogen seal oil unit in accordance with Section 5.6.

7.7.1.4 A flanged spool piece or equivalent arrangement should be provided to facilitate the separation of hydrogen supply where the generator is opened for maintenance.

7.7.1.5 For electrical equipment in the vicinity of the hydrogen handling equipment, including detraining equipment, seal oil pumps, valves, and so forth, see Article 500 of NFPA 70, *National Electrical Code*, and Section 127 of ANSI C2, *National Electrical Safety Code*.

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

7.7.1.7 Hydrogen lines should not be piped into the control room.

7.7.1.8 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.

7.7.2 Hydraulic Control System.

7.7.2.1 The hydraulic control system should use a listed fire-resistant fluid.

7.7.2.2 If a listed fire-resistant fluid is not used, hydraulic control equipment should be protected as described in 7.7.4.

7.7.2.3 Fire extinguishing systems, where required for hydraulic control equipment, should include reservoirs and stop, intercept, and reheat valves.

7.7.3 Lubricating Oil Systems.

7.7.3.1 Use of a listed fire resistant (i.e., less hazardous or less flammable) lubricating oil should be considered.

7.7.3.2 Lubricating oil storage, pumping facilities, and associated piping should comply with NFPA 30, *Flammable and Combustible Liquids Code*.

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

7.7.3.4 Curbing or drainage or both should be provided for the turbine lubricating oil reservoir in accordance with Section 5.6.

7.7.3.5 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.)*

7.7.3.6* Piping design and installation should consider the following protective measures:

(1) Welded construction
(2) Guard pipe construction with the pressure feed line located inside the return line or in a separate shield pipe drained to the oil reservoir and sized to handle the flow from all oil pumps operating at the same time
(3) Route oil piping clear of or below steam piping or metal parts
(4) Insulation with impervious lagging for steam piping or hot metal parts under or near oil piping or turbine bearing points
(5) Noncombustible coverings (flange guards) around the flange to reduce the possibility of oil spraying onto a hot surface

7.7.3.7 It is desirable to provide for remote operation, preferably from the control room, of the condenser vacuum break valve and lock out of 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 4.4.6 on fire emergency planning involving turbine lubricating oil fires.

7.7.3.8 Cable for operation of lube oil pumps should be protected from fire exposure. Protection can consist of separation of cable for ac and dc oil pumps or 1-hour fire resistive coating (derating of cable should be considered).

7.7.4 Fire Protection.

7.7.4.1 Turbine-Generator Area.

7.7.4.1.1* 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 (12.2 mm/min) over a minimum application of 5000 ft^2 (464 m^2).

7.7.4.1.2 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 (12.2 mm/min).

7.7.4.1.3* Lubricating oil reservoirs and handling equipment should be protected in accordance with 7.7.4.1.1. If the lubricating oil equipment is in a separate room enclosure, protection can be provided by a total flooding gaseous extinguishing system.

7.7.4.1.4* Protection for pedestal mounted turbine generators with no operating floor can be provided by recommendations 7.7.4.1 to 7.7.4.3 and by containing and drainage of oil spills and providing local automatic protection systems for the containment areas.

7.7.4.1.5 Foam-water sprinkler systems installed in place of automatic sprinklers described in Chapter 7 should be designed in accordance with NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, including the design densities specified in Chapter 7.

7.7.4.1.6 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.

7.7.4.2* Turbine-Generator Bearings.

7.7.4.2.1* Turbine-generator bearings should be protected with an automatic closed-head sprinkler system utilizing directional nozzles. Automatic actuation is more reliable than manual action. Fire protection systems for turbine-generator bearings should be designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over the protected area of all bearings.

7.7.4.2.2* Accidental water discharge on bearing points and hot turbine parts should be considered. If necessary, these areas can be permitted to be protected by shields and encasing insulation with metal covers.

7.7.4.3 Exciter. The area inside a directly connected exciter housing should be protected with a total flooding automatic carbon dioxide system.

7.7.4.4 Hydrogen Seal Oil. Hydrogen seal oil units should be protected in accordance with 7.7.4.1.

7.7.4.5 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 5.

7.8 Electrical Equipment.

7.8.1 Control, Computer, and Communication Rooms.

7.8.1.1 Control, computer, or telecommunication rooms should meet the applicable requirements of NFPA 75, *Standard for the Protection of Information Technology Equipment.*

7.8.1.2 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 are permitted to be omitted from this area.

7.8.1.3 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.

7.8.1.4 Cable raceways not terminating in the control room should not be routed through the control room.

7.8.1.5* Fire detection systems should alarm in a constantly attended area.

7.8.2 Cable Spreading Room and Cable Tunnels.

7.8.2.1 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 (12.2 mm/min) 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).

7.8.2.2 Cable spreading rooms and cable tunnels should be provided with an early warning fire detection system.

7.8.3 Grouped Electrical Cables.

7.8.3.1 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.

7.8.3.2 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.

7.8.3.3 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.

7.8.4 Switchgear and Relay Rooms. Switchgear rooms and relay rooms should be provided with smoke detection systems.

7.8.5 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.*

7.8.6* Transformers. Oil-filled main, station service, and start-up transformers not meeting separation or fire barrier recommendations in 5.2.4 or as determined by the fire risk evaluation should be protected with automatic water spray or foam-water spray systems.

7.8.7* Substations and Switchyards. Substations and switchyards located at the generating facility and 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 (1890 L) of oil should be in accordance with 5.2.4. Consideration should be given to water spray protection of transformers critical to the transmission of the generated power.

7.9 Auxiliary Equipment and Other Structures.

7.9.1 Emergency Generators.

7.9.1.1 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.*

7.9.1.2 Fire Protection.

7.9.1.2.1 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 (10.2 mm/min) density over the fire area.

7.9.1.2.2 Where gaseous suppression systems are used on combustion engines that can 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.

7.9.2 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 7.7.4.5.)*

7.9.3 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.

7.9.4 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 (10.2 mm/min) over the fire area.

7.9.5 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.*

7.9.6 Auxiliary Boilers.

7.9.6.1 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 7.5.

7.9.6.2 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 (10.2 mm/min) density. As a minimum, sprinkler or water spray protection should be provided as outlined in 7.5.1.

7.9.7 Vehicle repair facilities should meet the requirements of NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages.*

Chapter 8 Identification and Protection of Hazards for Internal Combustion Turbines

8.1 General.

8.1.1 Chapter 8 identifies fire and explosion hazards of internal combustion turbine electric generating units and specifies recommended protection criteria.

8.1.2 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 might be more suitable for one type of plant than the other.

8.2 Application of Chapters 4 through 7 and 11. The recommendations contained in Chapters 4 through 7 and 11 can 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 determination 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 might not exist (e.g., small units might have no cable spreading room or warehouse).

8.3 General Design and Equipment Arrangement.

8.3.1 Adequate separation should be provided, as determined by the fire risk evaluation, between the following:

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

8.3.2 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.

8.3.3 Compressors and regulating stations installed on-site should be protected in accordance with the recommendations of Chapter 8.

8.4 Unattended Facilities. Facilities that are operated unattended present special fire protection concerns.

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

8.4.2 The fire risk evaluation should address delayed response and lack of communication. This can 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 can necessitate automatic shutoff of fire pumps.

8.4.3 Automatic water mist suppression systems should be installed in accordance with their listing with respect to volume limitations, nozzle placement, and discharge durations. The arrangement will depend on the type of systems and the hazard protected. Thermal detection is recommended.

8.4.4 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.

8.4.5 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 coordinating effort should be reflected in the plant fire emergency plan. *(See Section 4.4.)*

8.4.6 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.

8.5 Combustion Turbine and Internal Combustion Engine Generators.

8.5.1 General.

8.5.1.1 The installation and operation of combustion turbine and internal combustion generators should be in accordance with NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, except as modified by Section 8.5.

8.5.1.2 Site-specific design considerations or manufacturer's typical design will govern what equipment has enclosures or how many separate enclosures will be provided for the combustion turbines or the internal combustion 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 internal combustion engine plants might involve enclosures for equipment, but more commonly engine generators are installed in a row in an open room or hall.

8.5.1.3 The major hazards associated with combustion turbine or internal combustion electric generator units are as follows:

(1) Flammable and combustible fuels
(2) Hydraulic and lubricating oils

8.5.1.4* 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 internal combustion engines have caused large external fires. Other hazards associated with the combustion turbine or internal combustion engine generator are as follows:

(1) Electrical equipment
(2) Large amounts of filter media and enclosure insulation

8.5.1.5 In the event of a problem with an internal combustion engine, shutdown might 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.

8.5.2 Prevention of Internal Fires in Combustion Turbines.

8.5.2.1* 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.

8.5.2.2* 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:

(1) Turbine speed sensor, independent of the main governor, for tripping on overspeed
(2) Vibration monitors at the main turbine bearings, for tripping on excessive vibration
(3) Turbine exhaust temperature monitor, for tripping on high temperature

8.5.2.3 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.

8.5.3 Prevention of External Fires in Combustion Turbines and Internal Combustion Engines.

8.5.3.1 Piping systems supplying flammable and combustible liquids and gases should be designed to minimize oil and fuel piping failures as follows:

(1) 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 in and at the points of entry at the engine interface.
(2) 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 can excite its natural frequency.
(3) 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.
(4) Instrumentation tubing, piping, and gauges should be protected from accidental mechanical damage. Sight glasses should be unbreakable.
(5) Where practical, lubricating oil lines should use pipe guard construction with the pressure feed line located inside the return line.

8.5.3.2 For internal combustion engines, the following monitors should be provided:

(1) Speed sensors, independent of governors
(2) High exhaust gas temperature alarm with shutdown

8.5.3.3* In many units the lubricating oil is used for both lubrication and hydraulic control. For combined systems, a listed fire-resistant 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.

8.5.3.4 Combustible gas detector(s) should be considered for the enclosure of gas turbines.

8.5.3.5 For recommendations regarding containment and drainage of liquids, see Section 5.6.

8.5.4* Fire Protection for Combustion Turbines and Internal Combustion Electrical Generators.

8.5.4.1 General.

8.5.4.1.1 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.

8.5.4.1.2 Water suppression systems, where provided, should follow the recommendations in Chapter 7 and the following criteria:

(1) 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.
(2) Automatic sprinkler or water spray protection should be provided for exposed oil piping and areas on the floor under the turbine where leaking oil can collect.
(3) 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.
(4) Fuel valves should be arranged to close automatically on water flow.
(5) Turbo-chargers on internal combustion engines constitute a part of the hazard and protection should be provided.

8.5.4.1.3 Lubricating oil reservoirs and handling equipment should be protected in accordance with 7.7.3.3 and 7.7.4.1.3. Where this equipment is located in open areas within a building, the building should be sprinklered in accordance with 7.7.4.1.1. Where lubricating oil reservoirs and handling equipment are installed outside, individual coverage is appropriate.

8.5.4.2 Total Flooding Gaseous Systems.

8.5.4.2.1 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 internal combustion 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 internal combustion engine air. This air flow will not stop immediately upon shutdown, and, therefore, it should be considered in the extinguishing system design.

8.5.4.2.2* 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 — that is, a minimum time of 30 minutes or to the rundown time of the turbine, whichever is longer. That would also result in a longer soak time for larger turbines, which can have rundown times exceeding 30 minutes.

8.5.4.2.3 System operations should be arranged to close the fuel valves.

8.5.4.2.4 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. The enclosure's integrity should be verified whenever it has been disassembled or modified. However, the enclosure integrity should be verified by a door fan test or other means of detecting leakage. The test should be conducted at least every 5 years.

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

8.5.4.2.6 For combustion turbines or internal combustion 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.

8.5.4.3 Total Flooding Water Mist Systems.

8.5.4.3.1 Where total flooding water mist systems are used, the system should be installed in accordance with NFPA 750, *Standard on Water Mist Fire Protection Systems*, and should be listed for the application. The system should be installed in accordance with the manufacturer's installation procedures.

8.5.4.3.2 The turbine enclosure should be arranged for reduced leakage by automatic closing of the doors, ventilation dampers, and automatic shutdown of fans and other openings. Fuel valves should be arranged to close automatically on system actuation.

8.5.4.3.3 The water (and air) supply should be sized to be capable of providing protection for as long as the hazards of hot metal surfaces above the autoignition temperature and uncontrolled combustible liquid flow exist (consult manufacturer for cooldown times). This has been shown to be 20 minutes for many areas, but can be substantially longer. This requirement can be met by cycling the mist discharge provided this is included in the listing and has shown to be effective in fire tests.

8.5.4.4 Localized Extinguishing Systems.

8.5.4.4.1 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.

8.5.4.4.2 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.

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

8.5.4.5 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.

8.5.5 Inlet Air System.

8.5.5.1 Air filters and evaporative coding media should be of a type that will not burn freely when exposed to fire. UL 900, *Standard for Safety Test Performance of Air Filters,* can be used as guidance.

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

8.5.5.3 Access doors or hatches should be provided for manual fire fighting on large air filter structures.

8.5.6 Generators.

8.5.6.1 Hydrogen systems should comply with recommendations in 7.7.1 and 7.7.4.4.

8.5.6.2 Fire protection should be provided in accordance with 8.5.4 for generator bearings and oil piping or any area where oil can flow, accumulate, or spray.

8.5.6.3* 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.

8.5.7* 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 8.5.4.1.

8.6 Electrical Equipment.

8.6.1 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.

8.6.2 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.

8.6.3 A smoke detection system should be installed to provide early warning and alarm functions in the event of an electrical fire within the enclosure.

8.6.4 An automatic suppression system should be considered for the enclosures.

8.7 Combined Cycle Units.

8.7.1 Heat Recovery Steam Generators. Heat recovery steam generators using supplemental firing should be designed and protected in accordance with Section 7.5. *(See NFPA 85, Boiler and Combustion Systems Hazards Code, for additional requirements.)*

8.7.2 Steam Turbines. Steam turbines, generators, and their associated hazards should be designed and protected in accordance with Section 7.7.

Chapter 9 Alternative Fuels

9.1 General. Chapter 9 identifies fire and explosion hazards of alternative fuel [e.g., refuse derived fuel (RDF), municipal solid waste (MSW), biomass]–fired electric generating plants and specifies recommended protection criteria that are common to all plants regardless of the fuel used.

9.1.1 The major fire and explosion hazards associated with mass burn units are as follows:

(1) Sourcing, receipt, handling, and storage of large quantities of alternative fuels.
(2) Unsuitable waste entering the facility. Examples include certain hydrocarbons, flammable liquids, metal dusts, acetylene, and explosives.
(3) Hydraulic and lubricating oils associated with the processing equipment.
(4) Improperly maintained electrical equipment.
(5) Large amounts of fuel accumulating in unsuitable areas as a result of spillage or handling.
(6) Inadequate dust control.

9.1.2 Plant Arrangement.

9.1.2.1 Specific 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.

9.1.2.2 Smoke or heat vents should be considered in accordance with 5.5.1 in areas such as the tipping/receiving floor, or in fuel storage areas.

9.1.2.3 There is an inherent dust potential associated with the processing of most alternative fuels. 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 7.4.3.4.)*

9.1.3 Boiler Feed Equipment.

9.1.3.1 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 85, Boiler and Combustion Systems Hazards Code.)*

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

9.1.4 Prevention of Fires and Explosions.

9.1.4.1 The facility personnel should ensure that fuel is continuously moved to the processing or storage areas. Vehicles loaded with fuel materials should not be parked in the building during idle periods.

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

9.1.4.3 A regular program of housekeeping should be established to keep concentrations of combustible material to a minimum.

9.1.4.4 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.

9.1.5 Fire Protection.

9.1.5.1* Hose stations designed in accordance with NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, should be located throughout fuel materials 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:

(1) Location and physical protection so as to avoid potential damage due to traffic patterns
(2) Size and number to be determined for unique plant geometry (e.g., push walls)
(3) Ease of use, maintenance, and storage, such as through the use of continuous-flow, noncollapsible hose reels
(4) Protection from freezing in unheated areas

9.1.5.2* Fuel handling structures and conveyors should be protected in accordance with 7.4.6.

9.1.5.3 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 (10.2 mm/min) should be provided.

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

9.1.5.4 Based on the combustible loading, location, and essential use, an automatic sprinkler system should be considered for dust collectors, baghouses, and cyclone type separators. *(Refer to 7.4.6.5.)*

9.2 Application of Chapters 4 through 7 and 11. The recommendations contained in Chapters 4 through 7 and 11 can 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 as follows:

(1) Where size and specific design eliminate certain hazards (e.g., H_2 seal oil units, cable spreading rooms, or warehouses)
(2) Where the fire risk evaluation indicates a single source of water (e.g., a single tank) is considered adequate and reliable

9.3 Mass Burn Fuels.

9.3.1 General. Section 9.3 identifies fire and explosion hazards that are unique to the use of 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.

9.3.2 Plant Arrangement.

9.3.2.1 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-hour fire separation.

9.3.2.2 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.

9.3.2.3 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 9.4.5)* 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:

(1) Locating the pulpit such that operator safety is not compromised
(2) Ability to have a clear and unobstructed view of all storage and charging areas
(3) Providing self-contained breathing apparatus for operator egress
(4) Providing direct communication with the boiler control room and floor manager
(5) Ability to activate fire protection equipment

9.3.2.4 Mass burn facilities utilizing hammermills and flailmills should refer to the criteria in 9.4.2.2.

9.3.3 Fire Protection.

9.3.3.1* 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 (10.2 mm/min) 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.

9.3.3.2* The MSW Storage Pit, Charging Floor, and Grapple Laydown Areas.

9.3.3.2.1 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 (8.1 mm/min) 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.

9.3.3.2.2 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 streams operating simultaneously. Due to frequency of use and potential for operator fire exposure, oscillating monitor nozzles with manual override should be provided.

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

9.3.4 Explosion Suppression. Mass burn facilities utilizing hammermills and flailmills for processing of oversize bulky waste should follow the recommendations of 9.4.3.

9.4 Refuse Derived Fuels (RDF).

9.4.1 General. Section 9.4 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.

9.4.2 Plant Arrangement.

9.4.2.1 Fire areas should be separated from each other by approved means. In addition to the applicable requirements of 5.2.1.2 and 5.2.1.3, it is recommended that, as a minimum, fire area boundaries be provided to separate the following:

(1) The tipping floor (including the MSW storage)
(2) The processing area
(3) RDF storage

9.4.2.2 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 can be ignited.

9.4.2.2.1 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 the following locations:

(1) Outside of, but sharing a common wall with, the main building
(2) Inside of the main building, along an outside wall
(3) Within the main building

9.4.2.2.1.1 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.

9.4.2.2.2 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 9.4.3.

9.4.2.2.3* 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.

9.4.2.2.4 Platforms at intermediate elevations should be of open grating to reduce obstructions to the effective vent area.

9.4.2.2.5 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*.

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

9.4.2.2.7 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 9.4.5.)*

9.4.2.2.8 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.

9.4.3 Prevention of Fires and Explosions in RDF Units. 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 7.4.3.4.)*

9.4.4 Fire Protection.

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

9.4.4.2 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 (10.2 mm/min) 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.

9.4.4.3* 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 (10.2 mm/min) 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.

9.4.4.4* The processing building should be provided with automatic sprinkler protection throughout. Systems should be designed for a minimum of 0.25 gpm/ft^2 (10.2 mm/min) 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).

9.4.4.5 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 (14.3 mm/min) 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.

9.4.4.6 The RDF boiler feed system area, including bins, hoppers, chutes, conveyors, and so forth, should be considered for automatic sprinkler protection. Where provided, the systems should be designed for a minimum of 0.20 gpm/ft^2 (8.1 mm/min) over the most remote 2000 ft^2 (186 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.

9.4.4.7 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 (10.2 mm/min) 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.

9.4.4.8 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.

9.4.5 Explosion Suppression.

9.4.5.1 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.)*

9.4.5.2 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.

9.4.5.3 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.

9.5 Biomass Fuels.

9.5.1 General. Section 9.5 identifies fire and explosion hazards that are unique to the processing of forest and agricultural by-products (e.g., wood chips, rice hulls, sugar cane) 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.

9.5.2 Plant Arrangement.

9.5.2.1 The initial biomass receiving and storage area, whether indoors or outdoors, should be designed in accordance with the following:

(1) NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*
(2) NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*
(3) NFPA 230, *Standard for the Fire Protection of Storage*
(4) NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*
(5) NFPA 1144, *Standard for Protection of Life and Property from Wildfire*

9.5.2.2 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.)*

9.5.2.3 Fire areas should be separated from each other by approved fire barriers, spatial separation, or other approved means. In addition to the requirements of 5.2.1.3, it is recommended that, as a minimum, fire area boundaries be provided to separate the following:

(1) The receiving/storage area
(2) The processing area

9.5.2.4 For biomass facilities utilizing processes described in 9.5.2.2, refer to 9.3.2.3.

9.5.3 Prevention of Fires and Explosions in Biomass Units.

9.5.3.1 Outdoor Storage. For the prevention of fires with outdoor storage of biomass, see NFPA 230, *Standard for the Fire Protection of Storage.*

9.5.3.2 Indoor Storage. For biomass materials subject to spontaneous ignition, the piles should be rotated on a regular basis.

9.5.4 Fire Protection.

9.5.4.1 For the fire protection of outdoor biomass material, see NFPA 230, *Standard for the Fire Protection of Storage.*

9.5.4.2* Biomass storage buildings should be provided with automatic sprinklers throughout. Systems should be designed for a minimum of 0.25 gpm/ft^2 (10.2 mm/min) 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).

9.5.5 Explosion Protection. Biomass units utilizing equipment capable of producing explosive concentrations of gases or dusts as described in 9.5.2.2 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.)*

9.6 Rubber Tires.

9.6.1 General.

9.6.1.1* Section 9.6 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).

9.6.1.2 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.

9.6.2 Initial Receiving and Storage Areas.

9.6.2.1 The initial receiving and storage areas should be located outdoors. The area should be secured and cleared of all vegetation within 100 ft (30 m) of tire storage. See Annex C of NFPA 230, *Standard for the Fire Protection of Storage*, for further guidance on pile size, separation, and access.

9.6.2.2* Where overhead cranes are used to load inside feed hoppers from inside the storage pits, the following should be considered:

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

9.6.2.3 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.

9.6.3 Prevention of Fires and Explosions in Scrap Rubber Tires. (Reserved)

9.6.4 Fire Protection.

9.6.4.1 For the water supply and fire protection requirements of outdoor storage of scrap rubber tires, see Annex C of NFPA 230, *Standard for the Fire Protection of Storage.*

9.6.4.2 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 (9.8 mm/min) over the entire pit area, with the protection area per nozzle not to exceed 100 ft^2 (9.3 m^2). Due to the extreme hazard, clearance between the top of storage and foam water spray systems should be minimized.

9.6.4.3* 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.

9.6.4.4 For protection and storage of scrap rubber tires indoors, refer to NFPA 230, *Standard for the Fire Protection of Storage*.

9.6.4.5 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 (12.2 mm/min) over the most remote 2500 ft^2 (232 m^2).

9.6.4.6 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.

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

9.6.5 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.)*

9.7 Other Alternative Fuels and Processes. Other alternative fuels (e.g., culm, peat, gob) 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 10 High Voltage Direct Current (HVDC) Converter Stations

10.1 General. Chapter 10 identifies the fire hazards and specifies recommended protection criteria for high voltage direct current (HVDC) converter stations and static var compensator/static var generator (SVC/SVG) facilities.

10.2 Application of Chapters 4 through 7 and 11. The recommendations contained in Chapters 4 through 7 and 11 can apply to HVDC converter stations and SVC/SVG. It is incumbent upon the fire risk evaluation to determine which recommendations apply to any specific HVDC or SVC/SVG facility. This determination 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 and SVC/SVG facilities.

10.3 HVDC Converter Stations.

10.3.1 General.

10.3.1.1 Section 10.3 identifies fire hazards that are associated with the operation of HVDC converter stations. Conditions that could cause a fire in high voltage converter equipment include the following:

(1) Loose electrical connections
(2) Electrical insulation or resistance breakdowns
(3) Overheated components
(4) Water leakage or intrusion (e.g., cooling system malfunction, roof leak)
(5) Foreign objects (e.g., tools, metal scrap, rubbish, vermin)

10.3.1.2 The hazards that could present a fire risk at a HVDC converter station include the following:

(1) Converter valve assemblies
(2) Converter transformers
(3) Oil-filled wall bushings
(4) Capacitors containing combustible dielectric fluid or polymers
(5) Station services and auxiliary high voltage equipment

10.3.2 Plant Arrangement.

10.3.2.1* 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 5.2.1.3. Unless consideration of the factors of 5.2.1.2 indicates otherwise, it is recommended that fire area boundaries be provided to separate the following:

(1) Service building
(2) Main control room
(3) Valve electronics rooms
(4) HVAC equipment rooms
(5) Relay room, SCADA room, and remote terminal unit room (RTU)

10.3.2.2 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:

(1) Valve tier levels, by adding to the bottom tray on each level
(2) Valve modules, by adding to the side of each tray section
(3) Grading capacitors, snubber circuits, and power supplies

10.3.2.3 Smoke or heat vents should be considered in accordance with 5.5.1.

10.3.2.4 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.

10.3.2.5 Outdoor converter transformers and oil-filled smoothing reactor(s) should be arranged in accordance with 5.2.3 and 5.6.6.

10.3.2.6 Drainage provisions should be provided for indoor and outdoor oil-filled wall bushings. Drainage should be arranged in accordance with Section 5.6. 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.

10.3.2.7 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.

10.3.3 Fire Prevention.

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

10.3.3.2 A fire emergency plan should be implemented in accordance with 4.4.4.

10.3.3.3 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.

10.3.3.4* 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.

10.3.4 Fire Protection.

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

10.3.4.2 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 arresters, or other energized electrical equipment.

10.3.4.3 Dry type AC/DC wall bushings, which do not necessitate fire detection or suppression systems, should be considered to eliminate the fire risk associated with oil-filled equipment.

10.3.4.4 Auxiliary equipment areas and other structures should be protected with automatic protection systems in accordance with Sections 7.8 and 7.9. Converter transformers should be protected in accordance with 7.8.7.

10.3.4.5 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.

10.3.4.6 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.

10.3.4.7 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 11 Fire Protection for the Construction Site

11.1 Introduction.

11.1.1 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 and potential for delays in construction schedules and plant startup, as well as protection of property.

11.1.2 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.

11.1.3 For fire protection for plants and areas under construction, see NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*. Chapter 11 addresses concerns not specifically considered in NFPA 241.

11.2 Administration.

11.2.1 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 the internal program as necessary using the measures outlined in this recommended practice.

11.2.2 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.

11.2.3 The fire prevention and fire protection program should include a fire risk evaluation of the construction site and construction activities at any construction site. *(See Chapter 5.)*

11.2.4 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 4.3 and 4.4 and 4.4.2, 4.4.4, and 4.4.5.

11.2.5 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.)*

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

11.2.5.2 Where partial construction activities occur on second and third shifts, the guard service rounds are permitted to be modified to include only unattended or sparsely attended areas.

11.2.5.3 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 are permitted to be omitted after the first round indicated in 11.2.5.1.

11.2.6 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 7.

11.2.7 In-service fire detection and fire extinguishing systems provide important protection for construction materials, storage, and so forth, even before the permanent hazard is present. Temporary fire protection systems can 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.

11.2.8 Construction and installation of fire barriers and protective opening devices (i.e., fire doors, dampers) should be given priority in the construction schedule.

11.3 Site Clearing and Construction Equipment.

11.3.1 Site Clearing.

11.3.1.1 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 1143, *Standard for Wildland Fire Management.* Contact should be made with local fire and forest agencies for current data on restrictions and fire potential, and to arrange for necessary permits.

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

11.3.1.3 Fire tools and equipment should be used for fire emergencies only and should be distinctly marked and maintained in a designated area.

11.3.1.4 Each site utility vehicle should be equipped with at least a portable fire extinguisher or backpack pump filled with 4 gal to 5 gal (15 L to 19 L) of water.

11.3.1.5 Cut trees, brush, and other combustible spoil should be disposed of promptly.

11.3.1.6 Where it is necessary to dispose of combustible waste by on-site 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 should obtain all appropriate permits prior to the start of work. *(See Section 11.2.)*

11.3.1.7 Local conditions can require the establishment of fire breaks by clearing or use of selective herbicides in areas adjacent to property lines and access roads.

11.4 Construction Warehouses, Shops, and Offices.

11.4.1 All structures that are to be retained as part of the completed plant should be constructed of materials as indicated in Chapter 5 and should be in accordance with other recommendations for the completed plant.

11.4.2 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.)*

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

11.4.4 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 in 11.4.4 through 11.4.10. 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.

11.4.4.1 Building construction materials should be noncombustible or limited combustible. *(See Chapter 5.)*

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

11.4.4.3 Air-supported structures sometimes are used to provide temporary warehousing space. Although the fabric envelope can 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 can leave the contents exposed to the elements.

11.4.5 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 (9.3 m^2) or where the occupancy presents a fire exposure, the enclosure should be protected with an approved automatic fire extinguishing system.

11.4.6 Storage of construction materials, equipment, or supplies that are either combustible or in combustible packaging should be prohibited in main plant buildings unless one of the following conditions applies:

(1) An approved automatic fire extinguishing system is in service in the storage area
(2) 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

11.4.7 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.

11.4.8 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*.

11.4.9 The handling, storage, and dispensing of flammable liquids and gases should meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*, NFPA 58, *Liquefied Petroleum Gas Code*; and NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*.

11.4.10 Vehicle repair facilities should meet the requirements of NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*.

11.5 Construction Site Lay-Down Areas.

11.5.1 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.

11.5.2 Combustible materials should be separated by a clear space to allow access for manual fire-fighting equipment *(see Section 11.8)*. Access should be provided and maintained to all fire-fighting equipment including fire hose, extinguishers, and hydrants.

11.6 Temporary Construction Materials.

11.6.1 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.

11.6.1.1 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.

11.6.1.2 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.

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

11.7 Underground Mains, Hydrants, and Water Supplies.

11.7.1 General.

11.7.1.1 Where practical, the permanent underground yard system, fire hydrants, and water supply (at least one water source), as indicated in Chapter 6, 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. If there is a possibility that the temporary system will be used for the life of the plant, then the temporary system should meet the requirements indicated in Chapter 6.

11.7.1.2 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.

11.7.2 Hydrants should be installed, as indicated in Chapter 6, 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.

11.7.3 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:

(1) 750 gpm (2839 L/min)
(2) The in-service fixed water extinguishing system with the highest water demand and 500 gpm (1890 L/min) for hose streams

11.7.3.1 The highest water demand should be determined by the hazards present at the stage of construction, which might not correspond to the highest water demand of the completed plant.

11.7.3.2 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.

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

11.8 Manual Fire-Fighting Equipment.

11.8.1* 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*.

11.8.2 Portable fire extinguishers of suitable capacity should be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*, as follows:

(1) Where flammable liquids are stored or handled
(2) Where combustible materials are stored
(3) Where temporary oil- or gas-fired equipment is used
(4) Where a tar or asphalt kettle is used
(5) Where welding, grinding, or open flames are in use

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

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

Annex A Explanatory Material

Annex A is not a part of the recommendations of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.4.4.1.2 Inspection intervals for unattended plants can be permitted to be extended to normal plant inspections.

A.4.4.4 Emergency conditions can warrant that breathing apparatus be readily available in the control room. Self-contained breathing apparatus should be considered for activities outside the control room.

A.4.4.5.2 Recommendations contained in NFPA 600, *Standard on Industrial Fire Brigades*, and 29 CFR 1910, Subparts E and L should be consulted for additional information.

A.5.2.1.3 Where the control room and computer room are separated by a common wall, the wall need not have a fire resistance rating.

A.5.2.2.1 Listed penetration seals for large diameter piping might not be commercially available. In such instances the design should be similar to listed configurations.

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

A.5.2.4.3 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 the width of the transformer oil containment. If columns supporting the turbine building roof at the exterior wall have a 2-hour 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.

A.5.2.4.5 A higher noncombustible shield can be permitted to be provided to protect against the effects of an exploding transformer bushing.

A.5.2.5.2 Where multiple transformers of less than 100 gal (379 L) capacity each are located within close proximity, additional fire protection can be required based on the fire risk evaluation.

A.5.3.2 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.

NFPA *101* allows additional means of egress components for special purpose industrial occupancies. These areas can 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.

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
(8) Electrostatic precipitators

A.5.6.2 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.

A.7.4.1.1 The Powder River Basin (PRB) of Montana and Wyoming has the largest reserves of low-sulfur coal in the United States (76 percent). PRB coal has gained popularity as an alternative to expensive scrubbers required to meet emissions standards when burning high-sulfur coal. PRB coal has one-half to one-sixth the sulfur content of most other coals. The following is a representative proximate analysis of PRB coals (ranges of PRB data published in "Guide to Coal Mines," Burlington Northern and Sante Fe Railway, courtesy PRB Coal Users' Group):

Fixed carbon:	32.06–40.00 %
Volatile matter:	27.70–32.66 %
Moisture:	23.80–31.80 %
Ash:	3.80–8.45 %
Sodium as a percentage of ash:	0.32–7.50 %
Sulfur:	0.20–0.80 %
Btu/lb:	8050–9500
Size:	Nominal 2 in. × 0 in.

Ash fusion temperature/reducing atmosphere:

Initial, °F:	2050–2268
Initial, °C:	1121–1242
Fluid, °F:	2142–2348
Fluid, °C:	1172–1287

PRB coal presents fire protection challenges due to spontaneous heating characteristics. Also, PRB is extremely friable, contributing to higher levels of dusting and spillage. Housekeeping, preplanning, coal handling equipment design, and fire protection system design are integral components to minimizing the risks associated with a PRB coal fire.

A.7.4.2.1 *Spontaneous Heating.* The chemical properties of coals that effect spontaneous combustion are oxygen content, moisture, impurities (especially sulfur in the form of pyrites), and volatiles. The physical properties are particle size and friability.

Spontaneous heating occurs due to oxidation of freshly exposed coal surfaces. For spontaneous heating to lead to ignition, sufficient air must be present and in contact with fresh (unoxidized) surfaces, yet without sufficient air movement to dissipate heat generated by oxidation. The oxidation rate of coal at ambient temperatures is determined by its rank, its exposed surface area, and the percentage of free oxygen in the atmosphere permeating the coal. Coal of low rank (soft coal) will have a higher oxidation rate than harder coal under the same conditions. Likewise, if coal is crushed to a finer particle size, more surface area will be exposed and the oxidation rate will increase. A reduction in free oxygen content in the atmosphere permeating the coal reduces the rate of oxidation (almost proportionately). Oxidation will continue at a reduced rate until the free oxygen is exhausted. Heat produced by spontaneous combustion will be absorbed by the coal, resulting in an increase in coal temperature. Due to the chimney effect, air infiltration leakage might be expected around the discharge valve or other bottom leaks of silos and bunkers or in the top 5 ft to 6 ft (1.5 m to 1.8 m) of the coal in the bunker. Therefore "hot spots" will tend to develop in the lower and upper portions of the coal in the silo and near any seams or openings that allow air infiltration. Inerting the coal with carbon dioxide or nitrogen and covering the top of the bunker to prevent air to cause spontaneous ignition is a common practice for forced and extended outage with coal in the bunker. As the coal temperature increases, the rate of oxidation will also increase. Due to the range and number of variables it is difficult to define the time to ignition of coal in storage.

Spontaneous heating can be mitigated by minimizing wetting of the coal, the duration of storage of the coal, and air movement in the silo.

Various designs can be used for piercing rod access ports for delivery of micelle-encapsulting agents with water. A minimum 4 in. (10.16 cm) diameter access port is recommended to facilitate insertion of the piercing rod. One such design is a 4 in. (10.16 cm) flanged connection with a blind flange. The interior of the access port should be filled with expanded foam (flush with the interior silo surface) to prevent coal from collecting in the access port. When use of a given access port is required, the foam is removed from the outside to allow insertion of the piercing rod. Platform space should be provided at access port locations as required to assemble the piercing rod in 5 ft (1.5 m) sections and to operate the hand line and eductor equipment.

A.7.4.2.2 *Silo Construction.* If the plant is designed to burn a type of coal that is considered prone to spontaneous combustion or one that has a high percentage of "volatiles," silos should be cylindrical with conical hoppers. The coal's angle of repose should be considered when designing the internal slope of the silo and hopper so that coal will flow freely (normally 60 degrees from the horizontal will be sufficient) to avoid arching and voiding. Air cannons located at the throat of the silo can be used to ensure that coal continues to flow. However, caution is necessary to ensure that air cannons are not utilized during a fire or where low coal levels could result in suspended coal dust entering the explosive range.

Experience indicates that low-sulfur Powder River Basin (PRB) coal is highly susceptible to spontaneous heating. For other coal types, experience indicates that coal volatility content above 38 percent might be conducive to spontaneous heating. The designer might consider inerting the silo if the volatiles content of the coal exceeds 38 percent or if PRB coal is used. Where the coal used has known spontaneous heating problems, special conveyors and chutes or pans can be provided to unload silos during forced outages.

A.7.4.2.3 *Silo Operations and Maintenance.* Where possible, coal silos should be operated at full capacity and coal should flow continuously. When silos are not operated at or near full volume, spontaneous combustion can occur at an increased rate. These conditions should be monitored periodically. Daily carbon monoxide samples should be taken at the top of each silo to establish a benchmark carbon monoxide level. Increased carbon monoxide levels can give an early indication of a hot spot or silo fire. Some experience in this area indicates that the carbon monoxide levels may rise days before fires are detected by other means. Silos should be run empty and inspected if the carbon monoxide levels exceed twice the benchmark concentration.

Dependent on bin, bunker, or silo construction, the internal space might allow the build-up of coal on its walls. Removing the coal from the bin, bunker, or silo wall can be employed to minimize the risk of spontaneous combustion of the trapped coal.

During planned maintenance outages, silos should be emptied and thoroughly cleaned of coal deposits. Operating procedures should ensure that magnetic separators are in service when coal is being conveyed into the silo, to avoid introducing tramp metals. Movement of tramp metal within the silo can result in an ignition source by striking metal parts, causing sparks that might ignite coal dust.

Three fires involving coal silos at one operating electric generating station occurred at or near cracks in the bottom cone of the silo. During maintenance outages the cones should be thoroughly inspected for cracks.

A long thermocouple [i.e., 10 ft (3 m)] connected to a portable instantaneous readout monitor can be employed. Pushing the thermocouple into the coal storage can detect developing hot areas or strata at different depths. Periodic monitoring of temperature change in these areas will help predict spontaneous combustion development and aid in response preplanning. Portable infrared heat detection or thermography has also proven useful in locating hot spots. Typical hot spots are easily detected when they are in the size range of 2 ft (0.6 m) in diameter. Hot spots in the center and higher up might not be found until the hot spot enters the cone area as the coal level drops.

A.7.4.2.6 All signs of spontaneous combustion and fire must be eliminated prior to the movement of coal.

Manual Fire Suppression. Fire fighting in coal silos is a long and difficult activity. Some fire-fighting operations have taken several days to completely extinguish a fire.

Smoldering coal in a coal bin, bunker, or silo is a potentially dangerous situation that depends on the location of the smoldering coal. There is a risk of a flash fire or explosion if the smoldering coal is disturbed. This risk should be considered in preplanning. Personnel responding to a coal fire should have proper personal protective equipment, including SCBA and turnout gear, and training in this hazard.

The area surrounding the smoldering coal should also be considered. The potential of developing an immediately dangerous to life and health (IDLH) atmosphere is possible. This should also be considered in preplanning.

Depending on the strategy selected, resource demands will be varied but challenging. Prefire planning is an important element in successful silo fire control and should be included in the initial plant fire risk evaluation *(see Section 5.1)* and the fire emergency plan *(see 4.4.4)*. Control room operators should be involved with the preplanning.

Use of Micelle-Encapsulating Agents. Use of micelle-encapsulating agents have found success in recent years, especially for PRB coal fires. Application of this agent is the preferred fire suppression method of the PRB Coal Users' Group for bunker, hopper, and silo fire protection *(see the PRB Coal Users' Group Recommended Practice, Coal Bunker, Hopper & Silo Fire Protection Guidelines)*.

Baseline guides and procedures for preplanning and applying micelle-encapsulating agents to these fires are included in the PRB Coal Users' Group document. These guides and procedures can be used as a starting point to customize the approach for the specific facility. The document is available to members of the PRB Coal Users' Group online at www.prbcoals.com.

The application of micelle-encapsulating agents can be enhanced by using an infrared camera to search for hot spots, either on the sides or top of the silo, to facilitate injection of the agent as close as possible to the fire area. The infrared imagery can be used to evaluate performance and monitor progress of the attack. The water/agent solution must penetrate to the seat of combustion to be effective. This penetration can be affected by the degree of compaction, voids, rate of application, evaporation rate, and so forth. Run-off must be drained through feeder pipe and will require collection, clean-up, and disposal. Micelle-encapsulating agents are designed to be environmentally friendly (non-corrosive, non-toxic, non-hazardous, and fully biodegradable).

Use of Class A Foams and Penetrants. Use of Class A foams and penetrants have found some success, but it has been difficult to predict the resources required for successful fire control. The agents generally require mixing with water prior to application, usually in the range of 1 percent by volume, mixed in a manner similar to Class B agents. While the typical application of Class A foam is to fight wildland fires at 1 percent, many plants have reported success with using Class A foams at 0.1 percent. This causes the agent to act as a surfactant. Higher proportions have caused excessive bubble accumulation that impedes penetration into the coal.

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Use of Inerting Gas. Carbon dioxide and nitrogen have been used successfully as gaseous inerting systems. Carbon dioxide vapor, with a density of 1.5 times that of air, has proven to be effective in quickly establishing an inert atmosphere in the space above the coal, which prevents the creation of an explosive atmosphere in that space.

At the same time the CO_2 vapor can be injected into the stored coal from the lower part of the silo, where fires are most likely to originate. This CO_2 inerts the voids between the coal pieces while filling the silo from the bottom up with CO_2 vapor. The CO_2 vapor injection rate is that needed to exceed any losses at the bottom of the silo while pushing the inert gas up through the coal at a reasonable rate. (Very tall silos require intermediate injection points for the CO_2 vapor between the top and bottom of the silo.)

Since carbon dioxide is stored as a compressed liquified gas, it must be vaporized before injection into the silo. External vaporizers are used and sized to handle the maximum anticipated CO_2 vapor flow rates.

It is common practice to monitor the carbon monoxide (CO) level while inerting with CO_2. If the CO level does not decrease, the controls on the CO_2 system are designed to allow for increasing the inerting rate. The flow can also be reduced to conserve the CO_2 supply once fire control has been established.

A large imbedded coal fire provides a heated mass that will be extremely difficult to extinguish with CO_2 alone. It is, however, important that supplemental fire fighting be done in an inert environment. The CO_2 system's primary mission is to prevent the large fire from occurring by detecting the fire early by the CO detectors while it is still small and then inerting to contain and extinguish.

Bulk liquid CO_2 units are generally used, but cylinders can be used for inerting smaller silos. (The bulk CO_2 supply is frequently used for other applications such as pulverizer inerting, generator hydrogen purge, and some fire suppression system applications in the turbine building.) The bulk CO_2 units have the capability of being refilled while they are being used. For the smaller silos, CO_2 vapor is withdrawn from manifolded cylinders without siphon tubes.

Carbon dioxide inerting has a beneficial effect as soon as it reaches the oxidizing coal. As the supporting oxygen level drops, less heat is generated, helping to limit fire spread. But to totally extinguish any large burning coal mass can require a very high CO_2 concentration held for a long time since the cooling capacity of the CO_2 is relatively small and the coal itself tends to retain heat.

The CO_2 system should be considered as a fire prevention/fire containment system. The system can be operated from a dedicated manual release station or by the plant programmable logic controller (PLC) from the control room. Plant personnel need not be involved except to adjust the CO_2 flow rates as needed to manage the inerting or fire suppression.

When carbon dioxide is used, there is a risk of oxygen depletion in the area above, around, or below a silo, bin, or bunker. Areas where gas could collect and deplete oxygen, which might include the tripper room and areas below the discharge feeder gate, should be identified with appropriate barriers and warning signs.

Nitrogen has been used successfully to inert silo fires. It is applied in a manner very similar to carbon dioxide. A notable difference is that nitrogen has about the same density as air (whereas carbon dioxide is significantly more dense.) Therefore, it must be applied at numerous injection points around the silo to ensure that it displaces available oxygen, which results in the need for more injection equipment and a larger quantity of agent.

Emptying the Silo. The silo can be unloaded through the feeder pipe, but it is a dirty, messy operation. It is necessary to bypass the feeder belt and to dump the coal onto the floor of the power house at the feeder elevation. A hose crew should be available to extinguish burning coal as it is discharged from the silo. There is a risk that dust raised during this activity can ignite explosively. High expansion foam can be applied.

Carbon monoxide produced during the combustion process will also tend to settle in the lower elevation and can be a hazard to the hose crew. Once spilled and extinguished, it is usually necessary to shovel the coal into a dump truck for transport back to the coal pile.

Manual Fire Fighting. Regardless of the type of suppression approach selected, prefire planning is an important element of successful fire control and extinguishment. All necessary resources should be identified and in place prior to beginning fire suppression activities. If necessary materials are not stockpiled on-site, suppliers should be contacted in advance to ensure that equipment and supplies are available on relatively short notice.

The personnel requirements for this fire-fighting activity should be identified in advance. Personnel should be trained and qualified for fire fighting in the hot, smoky environment that might accompany a silo fire. This training includes the use of self-contained breathing apparatus and personal protective equipment. Personnel engaged in this activity should be minimally trained and equipped to the structural fire brigade level as defined in NFPA 600, *Standard on Industrial Fire Brigades.* If station personnel are not trained in use of self-contained breathing apparatus, it will be necessary for the public fire department to perform fire-fighting in these areas. Station personnel are still needed to assist with operational advice and guidance. The public fire-fighting agency that responds to a fire at the facility should be involved in preplanning fire-fighting activities for silo fires. The public fire service might need specific instruction concerning operation and potential hazards associated with coal silo fires as well as operation in the power plant environment. It is important that the responding fire service be supplied information and guidance at every opportunity.

The resources of the station and the local fire service need to work in concert, including working with control room operators and keeping them apprised of fire control operations. Preplanning should include administrative details such as chain of command, access, and so forth. Operations should be coordinated by an established incident command system in conformance with NFPA 1561, *Standard on Emergency Services Incident Management System.* All personnel should be familiar with and practice this system prior to the event.

A.7.4.3 *Coal Dust Hazards.* The hazard of any given coal dust is related to the ease of ignition and the severity of the ensuing explosion. The Bureau of Mines of the U.S. Department of Interior has developed an arbitrary scale, based on small scale tests, that is quite useful for measuring the potential explosion hazard of various coal dusts. The ignition sensitivity is a function of the ignition temperature and the minimum energy of ignition, whereas the explosivity is based on data developed at the Bureau of Mines. The test results are based on a standard Pittsburgh coal dust taken at a concentration of $0.5/ft^3$ ($0.5\ kg/m^3$) ounces per cubic foot. The explosibility index is the product of ignition sensitivity and explosion severity. This method permits evaluation of relative hazards of various coal dusts.

When coal silos are operated with low inventory there is potential for suspended coal dust to enter the explosive range. As in spontaneous heating, the explosive range and potential for explosion are based on the above variables.

A.7.4.3.2 Constructing enclosure hoods at transfer points can minimize the amount of dust released to surrounding areas, which can reduce the need for dust collection.

A.7.4.3.5 The use of fire protection water spray systems can be an effective way of cleaning conveyor systems if this function is properly considered during the design of the systems. Alarm actuation and automatic belt shutdown features should not be actuated when water spray systems are being used for cleaning purposes.

A.7.4.6.2 In many cases, coal conveyors within structures are equipped with dust collection hoods or "skirting," which makes the protection of the top conveyor belt(s) difficult by conventional placement of sprinklers and nozzles. In plants where high pyritic coals are being used, it is recommended that protection be provided inside of these hoods as well as all drive pulley enclosures. Care should be taken when installing the sprinklers or nozzles to allow for easy access to these devices for inspection purposes.

Where conveyors are located in enclosed gallery structures, protection for the top belt commonly takes the form of sprinklers or nozzles at the ceiling of the gallery with a second level of protection for the return belt. In this instance, the entire width of the gallery should be included in the design area for the upper level of protection.

A.7.4.6.2.1 Water spray systems should be considered for enclosed conveyors that are inclined because of the greater potential for rapid fire spread.

A.7.6.2.3 Special detection systems currently used are the following:

(1) Infrared detection systems to monitor rotor or stator surfaces
(2) 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.

A.7.6.4.2 Temperature sensors alone might not be adequate to provide early warning of a fire in an electrostatic precipitator.

A.7.6.5 *Scrubber Fire Loss Experience.* There have been at least three major fires involving scrubbers with plastic lining or plastic fill. They have the following factors in common:

(1) Fire occurred during an outage
(2) Fire was detected immediately
(3) Fire was caused by cutting and welding
(4) Rapid fire spread prevented access to the interior of the scrubber, which made manual fire fighting ineffective

The following are brief summaries of the losses reported to date.

Fire No. 1. The scrubber was 36 ft (11 m) in diameter and 139 ft (42 m) high. The scrubber contained two sections of polypropylene packing: one section was 4 ft (1.2 m) thick and one section was 3 ft (1 m) thick. The 3 ft (1 m) thick section was removed at the time of the fire. Both layers of packing extended across the full diameter of the tower. An outside contractor was making repairs on a turning vane at the top of the scrubber. A welding blanket had been placed over the top of the fill. Sparks from the welding operation fell through the wood work platform and ignited the polypropylene packing 30 ft (9 m) below. The fire was detected immediately. Plant employees reacted rapidly and followed procedures established in advance. They actuated the demister spray nozzles, then closed access doors and the outlet damper to isolate the scrubber. Plant employees used 1½ in. (3.8 cm) hose on the outside of the duct. The public fire department responded. Total fire duration was two minutes. Property damage was estimated at $5 million, and the outage was 41 days.

Fire No. 2. There were four scrubbers in one building. The scrubbers were 30 ft × 30 ft × 80 ft (9 m × 9 m × 24 m) high. The scrubbers had an extensive amount of plastic packing and were lined. Maintenance was being performed on one of the scrubbers. A crew planned to make repairs to the liner near the top of the scrubber. The repair work involved cutting and welding operations. Hot metal fell down inside the scrubber. A small fire was observed in the lower part of the scrubber that quickly spread and burned out the lining and packing. Fire burned through the expansion joint on the top of the scrubber and spread throughout the penthouse, with damage to building structural steel in the area above the scrubber. Property damage was estimated at $7 million, and the outage was about 8 months. This was due to the need for the replacement of the shell.

Fire No. 3. There were three absorber towers in one building. The towers were 40 ft × 65 ft × 185 ft (12.1 m × 19.7 m × 56 m) high. The scrubbers were lined with a rubber coating and had polypropylene mist eliminators. Workers were in the exhaust duct of one of the scrubbers attempting to seal small holes in the duct. Plastic sheeting was used to protect an expansion joint. Sparks from the welding operation ignited the plastic. Fire was detected immediately. Portable extinguishers were used to fight the fire. The fire quickly spread to wood scaffolding. The plant fire brigade responded but could not enter the duct due to dense smoke. Fire spread to the polypropylene mist eliminator and the rubber lining in the scrubber. Heat from the fire vented into the building, collapsing the roof. The scrubber was destroyed. Property damage was estimated at $42 million. The station was under construction, and its completion was delayed 2 years by the fire.

A.7.7.3.6 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.

A.7.7.4.1.1 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 can be necessary.

A.7.7.4.1.3 If the lubricating oil reservoir is elevated, sprinkler protection should be extended to protect the area beneath the reservoir.

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.

A.7.7.4.1.4 Above the operating floor, ceiling level sprinkler systems might 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)].

A.7.7.4.2 Additional information concerning turbine-generator fire protection can be found in EPRI Research Project 1843-2 report, *Turbine Generator Fire Protection by Sprinkler System.*

In February 1997 the National Institute of Standards and Technology published NIST Report Technical Note 1423, "Analysis of High Bay Hanger Facilities for Fire Detector Sensitivity and Placement." This report provides design recommendations for sprinkler and detection systems (protecting fuel pool fires) at those facilities, which can provide some design guidance if sprinkler systems are installed at the ceiling level of the turbine building.

However, turbine building hazards include pool fires and three-dimensional and spray fires. Without further testing, such systems should not be considered to provide equivalent protection to the turbine building systems recommended in the body of NFPA 850. If used in addition to those recommended systems, a properly designed ceiling level sprinkler system can provide additional protection for the turbine building roof if exposure to a large fire on the operating floor is a concern.

A.7.7.4.2.1 Automatically actuated systems have proven to actuate properly under fire conditions and are not prone to spurious actuation. If a manually operated water system is installed, consideration should be given to a supplemental automatic gaseous fire extinguishing system.

A.7.7.4.2.2 The 2000 edition of NFPA 850 allowed manual operation of bearing protection systems. In most incidents involving bearing oil releases this would be adequate. In some types of release, such as seal oil failures, that might not allow the operator time to activate the system. There are some turbine buildings where the control room is not located in the turbine building, which would also delay response.

If turbine-generator bearings are protected with a manually operated sprinkler system, the following should be provided:

(1) Manual activation should be from the control room or a readily accessible location not exposing the operator to the fire condition. Staffing of plant should be sufficient to promptly handle this function as well as other responsibilities during an emergency of this nature.
(2) Automatic fire detection should be provided over the area of each bearing and within the skirting of the turbine where a potential for oil to pool can alert operators to a fire condition.
(3) Documented procedures should be in place with authorized approval given to operators to activate the system if necessary in a fire condition.
(4) Periodic training should be given to operators regarding the need for prompt operation of the system.

A.7.8.1.5 Early detection of fire in the turbine building is important for effective emergency action. Control rooms in some plants are outside the turbine building, and operators make hourly rounds, which improves operator safety and ability of the operator to remain in the room in a fire emergency but could result in a delay in fire detection.

A.7.8.6 In recent years some transformers have been designed with relatively high design temperatures. Operation of the cooling fans can release large amounts of heat that can inadvertently trip deluge systems using rate-of-rise or rate-compensated heat detection equipment. To avoid these inadvertent trips, fixed temperature heat detection systems should be used to activate transformer deluge water spray systems.

A.7.8.7 For information pertaining to fire protection guidelines for substations, see ANSI/IEEE 979, *Guide for Substation Fire Protection.*

A.8.5.1.4 Internal combustion electric plants do not normally use large amounts of filter media and enclosure insulation.

A.8.5.2.1 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.

A.8.5.2.2 Monitors for parameters in 8.5.2.2(2) and 8.5.2.2(3) should have a lower alarm point to alert operators of deteriorating operating conditions. See ANSI B133.4, *Gas Turbine Control and Protection Systems.*

A.8.5.3.3 Internal combustion engines do not normally have any hydraulic systems.

A.8.5.4 Fires in many combustibles will not be totally extinguished during the gas discharge period.

Where this recommended practice does not specify a holding time, maintaining an extinguishing concentration beyond the end of the discharge period can still be appropriate.

Holding the design concentration can be accomplished by having an enclosure that is tight enough to maintain this concentration for the necessary duration. It can also be accomplished by extending the flooding discharge for a longer period of time. For example, a 34 percent CO_2 concentration is wanted to be held for 3 minutes. The initial discharge would be 1 minute, but the system is designed to keep the discharge going long enough that the resultant buildup of CO_2 gas concentration combined with the hazard leakage is such that the hazard is still flooded to the 34 percent level at the end of the 3 minutes (or whatever holding time is appropriate).

Another method that has been done (but is not generally recommended) is, where the system equipment permits, to open the gas discharge valve for the designed initial discharge period to create a concentration that is higher than needed, at which point the valve is closed and the gas concentration starts to decay. Sometime later the valve is opened again to rebuild the gas level, with the necessary cycling continuing so as to keep a gas concentration for however long is required.

However, most often the requirement for holding the extinguishing concentration is met using a supplemental discharge that starts with the flooding discharge but continues past the end of that discharge to the end of the holding period. That discharge not only makes up for gas lost from the enclosure during the holding time but also stirs the gas/air concentration within the protected volume to prevent the development of an interface (created when the heavier air/gas concentration leaks out and is replaced by lighter fresh air that rises to the top of the hazard, creating a space at the top of the hazard with less than the required gas concentration). An example of where this would be a problem is an electrical room with electrical cabling near the ceiling.

Having discussed the need for an extended gas concentration holding time and several methods of providing same, we need to look at how to determine the amount of that extended discharge.

First of all it is very important that there be a full understanding of the configuration of the hazard to determine if flooding is practical and, if so, what the requirements are.

An example: A project recently came to light where protection was required for a room housing a large transformer. The proposed arrangement was for the bus from the transformer to rise to supports from the ceiling, run to a wall, and drop through a fire-resistive duct to a switchgear room below. The only uncloseable opening in the transformer area was to be the open top of the duct, which would make a flooding system of the transformer room doable. However, when installed, the bus dropped straight down through a large hole in the floor to an open area below, creating a totally different hazard.

If the enclosure can be tested for integrity by a door fan test, this will give an indication of the potential gas loss rate. However, this test only quantifies the amount of opening, not the location of the opening. Low level openings are bad, while opening above the height of the hazard protected in the enclosure can actually be beneficial in a gas flooding situation. In addition, most of the industrial applications of gas flooding systems do not lend themselves to this type of a test.

Records should be kept of the performance of all discharge tests as there could be an opportunity to use a previous test on a similar hazard to determine the amount of extended discharge needed on the new project.

Also, experience can be taken advantage of, as follows:

Example: A concentration is needed to be held for 20 minutes, and it is a reasonably tight enclosure where losses of a percent or two per minute might be expected (e.g., 40 percent over the 20 minutes). This information is the basis of the preliminary design, and the gas requirements would be estimated accordingly.

Gas losses after a discharge are a function of the gas concentration used and the size and location of the uncloseable openings, which can usually be identified and located by a proper job site survey of an existing facility.

Then there is a trade-off of the cost and suitability of sealing some or all of the obvious openings vs. the cost of adding gas to the suppression system. But it is important that when a system is installed, where an extended discharge is required, there be added agent (or the provision to add agent) so that, when the hazard is tested and it fails to hold concentration, there is not a major problem in system adequacy.

Note: NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, paragraph 4.4.3.3.4 requires that each CO_2 system be given a full discharge test unless waived by the authority having jurisdiction. Preliminary testing to determine whether the concentration will hold or not is highly recommended if there are questions in this regard.

Where gaseous agent systems of this type are quoted, it is common practice for the supplier to identify how much leakage he has estimated and the basis of his estimate. The supplier then identifies that it is the responsibility of others to find and close the openings. It should also be recognized that the potential for uncloseable openings increases over time as the facility or equipment used is modified and maintained. Therefore, periodic retesting is recommended. Again, it should be assumed that gas losses in the event of a discharge will be greater and, hence, the system should be adequate to deal with these losses.

A.8.5.4.2.2 Proper gaseous extinguishing system design dictates that the design concentration be held in the compartment for the cooling time specified in 8.5.4.2.2 to take place. This time 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 extended discharge usually requires discharge testing to determine if design concentrations can be maintained. Where gas concentrations cannot be effectively maintained, an alternative system, such as a high-expansion foam or water extinguishing system, can be desirable.

A.8.5.6.3 The type of generator used with internal combustion engines is normally provided with an open drip-proof enclosure. Shielding might be appropriate with a water system — that is, sprinklers or deluge.

A.8.5.7 Large internal combustions are started with compressed air from an air receiver and do not require starting the engine.

A.9.1.3.2 For personnel safety considerations, see NFPA 85, *Boiler and Combustion Systems Hazards Code*, for further guidance.

A.9.1.5.1 Based on plant geometry, combustible loading, and staff size, a 250 gpm (946 L/min) monitor nozzle could be needed in lieu of or in conjunction with hose.

A.9.1.5.2 Conveyors can be considered protected by overhead building protection if not enclosed or hooded.

A.9.3.3.1 The requirements are based on storage heights not exceeding 20 ft (6.1 m).

A.9.3.3.2 See NIST Report Technical Note 1423, "Analysis of High Bay Hanger Facilities for Fire Detector Sensitivity and Placement."

A.9.4.2.2.3 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.

A.9.4.4.1 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 could be permitted to be provided through operator action in accordance with operating procedures.

A.9.4.4.3 The requirements in 7.4.4.7 are based on storage heights not exceeding 20 ft (6.1 m).

A.9.4.4.4 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.

A.9.5.4.2 Biomass fuels exhibit a wide range of burning characteristics and upon evaluation can require increased levels of protection.

A.9.6.1.1 In general, rubber tires have a Btu content of 15,000 Btu/lb (7180 J/kg), roughly two to three times that of wood or RDF.

A.9.6.2.2 For additional guidance on cranes and storage pits, refer to 9.4.2.

A.9.6.4.3 Addition of foam to the monitor nozzles should be considered.

A.10.3.2.1 If the Relay, SCADA, or RTU equipment is located in the main control room, fire partition barriers are not required for this equipment.

A.10.3.3.4 Control room operator fire emergency training should include, but not be limited to, the following:

(1) Station emergency grounding procedures
(2) Valve hall clearance procedures
(3) Electrical equipment isolation
(4) Timely communication of all fire events to the responding fire brigade and the fire department

A.11.8.1 Mobile fire-fighting equipment can be utilized to provide necessary first aid fire-fighting equipment.

Annex B Sample Fire Report

This annex is not a part of the recommendations of this NFPA document but is included for informational purposes only.

B.1 Figure B.1 is one example of a typical fire report to be used by the fire brigade after an incident.

Annex C Fire Tests

This annex is not a part of the recommendations of this NFPA document but is included for informational purposes only.

NOTE: Footnotes refer to reference list numbers at end of Annex C.

C.1 This annex summarizes the results of fire tests in which automatic sprinklers or water spray systems were used to extinguish or control fires in oil and grouped cables. Also included in this annex are results of tests conducted on fiberglass stack liners.

C.2 Combustible Oil Fire Tests.

C.2.1 General. Oils (except for crude oil) handled in bulk in power stations are limited to combustible liquids that lend themselves to control and extinguishment by water-type protective systems.

In order to ensure satisfactory results on such fires, the system design should take into account the physical nature of the expected fire, which will take one or more of three forms: a pressure jet or spray, a three-dimensional rundown of burning fuel over equipment and structures, or a spill or pool of fuel.

Fire experience with liquid fires in power stations confirms that a fire frequently displays multiple characteristics. A turbine-generator fire frequently originates as a spray fire at a bearing with burning oil running down to lower levels of the station where a spill or pool fire results. Similarly, a leak at an oil-fired boiler produces a spray fire with burning oil running down the boiler wall to a lower floor. A hydraulic oil leak on a fan drive likewise combines spray fire and spill fire characteristics.

A protective system is expected to control or extinguish a liquid fire, as well as provide exposure protection for the structure and equipment in the vicinity of the fire. The oil fire tests summarized in C.2.2 indicate that complete extinguishment of pressure jet or spray fires can be difficult to achieve at any practical application density. The tests also show that spill or pool fires can be controlled, and equipment and structures in the general area protected, with area sprinkler protection operating at moderate densities [0.15 gpm/ft^2–0.20 gpm/ft^2 (6.1 mm/min–8.1 mm/min)]. Where the probable location of spray fires can be identified (e.g., exposed pipe runs without guard pipe or specific items of equipment), high-velocity directional spray nozzles of open or fused type operating at applied densities of approximately 0.25 gpm/ft^2 (10.2 mm/min) can radically limit the damage area resulting from a jet or spray fire.

The design specifics for water protective systems should be covered by the fire risk evaluation based on the conditions existing in a particular plant.

SAMPLE FIRE REPORT

Name of company: ____________________

Date of fire: __________ Time of fire: __________ Operating facility: ____________________

Under construction: ____________________

Plant or location where fire occurred: ____________________

Description of facility, fire area, or equipment (include nameplate rating) involved: ____________________

____

____

Cause of fire, such as probable ignition source, initial contributing fuel, equipment failure causing ignition, etc.:

____

____

____

Story of fire, events, and conditions preceding, during, and after the fire: ____________________

____

____

____

Types and approximate quantities of portable extinguishing equipment used: ____________________

____

____

____

Was fire extinguished with portable equipment only? __________ Public fire department called? __________

Employee fire brigade at this location? __________ Qualified for incipient fires? __________

For interior structural fires? ____________________

Was fixed fire extinguishing equipment installed? ____________________

Type of fixed extinguishing system: ____________________

Automatic operation: __________ , manually actuated: __________ , or both: __________

Specific type of detection devices: ____________________

Did fixed extinguishing system control? __________ and/or extinguish fire? __________

Did detection devices and extinguishing system function properly? ____________________

If no, why not? ____________________

____

Estimated direct damage due to fire: $ __________ , or between $ __________ and $ __________

Estimated additional (consequential) loss: $ __________ Nature of additional loss: __________

____

Estimated time to complete repairs/replacement of damaged equipment/structure: ____________________

Number of persons injured: __________ Number of fatalities: __________

What corrective or preventive suggestions would you offer to other utilities who might have similar equipment, structures, or extinguishing systems? ____________________

____

____

Submitted by: ____________________ Title: ____________________

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FIGURE B.1 Example of a Fire Report.