

NFPA® 850

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

2015 Edition



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NFPA® 850

Recommended Practice for

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

2015 Edition

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. It was issued by the Standards Council on November 11, 2014, with an effective date of December 1, 2014, and supersedes all previous editions.

This edition of NFPA 850 was approved as an American National Standard on December 1, 2014.

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 fire suppression systems, and additional requirements were added for water mist fire suppression systems.

The 2005 edition of NFPA 850 underwent 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 were renumbered.

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

The 2010 edition of NFPA 850 included a chapter containing recommendations for a fire protection design process and fire protection design basis documentation (the new Chapter 4). The chapter on fire risk control program was moved to Chapter 16. New chapters on wind turbine generating facilities, solar thermal power generation, geothermal power plants, and integrated gasification combined cycle (IGCC) generating facilities (Chapters 10–13) were added.

The use of compressed air-foam systems and fast-depressurization systems were recognized, and recommendations for the use of these systems included.

The 2015 edition has undergone a significant revision with the merger of NFPA 851. The recommendations contained in NFPA 850 and 851 were aligned, and a new chapter (Chapter 14) was created to provide recommendations specific to hydroelectric generating plants. Recommendations for aerosol extinguishing systems have been added. Recommendations for active carbon injection systems have been added to Chapter 7, and Chapter 11 has been expanded to provide recommendations for fire and life safety involving photoelectric solar power plants.



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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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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 F. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. 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 F.

Chapter 1 Administration

1.1 Scope. This document provides recommendations 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; and fuel cells are addressed in NFPA 853.

1.2 Purpose.

1.2.1 This document is prepared for the guidance of those charged with the design, construction, operation, and protection of electric generating plants and high voltage direct current converter stations that are covered by the scope of this document.

1.2.2 This document provides fire hazard control recommendations for the safety of construction and operating personnel, the physical integrity of plant components, and the continuity of plant operations. Specific concerns are generalized and categorized as shown in 1.2.2.1 through 1.2.2.4.

1.2.2.1 Protection of Plant Personnel. Risk of injury and loss of life, in the event of fire, should be controlled. Specific criteria should be established for means of egress. When for plant safety and emergency response reasons personnel are not able to evacuate immediately, specific criteria for ensuring their safety until they can evacuate and safe passage to egress routes should be established.

1.2.2.2 Assets Protection. The large capital costs of the structures, systems, and components for the facilities addressed in

this recommended practice create financial risks for the owners, investors, and financiers. Specific criteria should be established for the mitigation of the risks from fires exposing these assets.

1.2.2.3 Business Interruption. The ability of these facilities to generate and transmit electricity is important not only to the owners of the facilities but also to the consumers of that energy, including the public. Specific criteria for managing the effects of fire on the ability to generate and transmit power should be developed, based on economic and societal considerations.

1.2.2.4 Environmental Protection. Fires in these facilities have the potential of creating environmental impact, by damaging pollution control systems and components and by creating unwanted releases to the environment from the fire and fire-fighting activities. Specific criteria should be established to control the impact of fire and fire-fighting activities on the environment.

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 applicable factors involved. This modification should be made only after following the methodology described in Chapter 4 and documented in the Fire Protection Design Basis document.

1.4 Equivalency. Nothing in this recommended practice is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this recommended practice.

1.4.1 Equivalency should be demonstrated following the methodology described in Chapter 4 and documented in the Fire Protection Design Basis document.

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 1, *Fire Code*, 2015 edition.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2013 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2010 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2015 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 2015 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2013 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2013 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2012 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2015 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2013 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2013 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2013 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2013 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2014 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2015 edition.

NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, 2015 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 2011 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2015 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2014 edition.

NFPA 54, *National Fuel Gas Code*, 2015 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2013 edition.

NFPA 56, *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, 2014 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2014 edition.

NFPA 59, *Utility LP-Gas Plant Code*, 2015 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, 2013 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, 2013 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2013 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2014 edition.

NFPA 70®, *National Electrical Code®*, 2014 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*, 2013 edition.

NFPA 75, *Standard for the Fire Protection of Information Technology Equipment*, 2013 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 2014 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2013 edition.

NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, 2012 edition.

NFPA 85, *Boiler and Combustion Systems Hazards Code*, 2015 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2015 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2015 edition.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems*, 2015 edition.

NFPA 92, *Standard for Smoke Control Systems*, 2015 edition.

NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*, 2014 edition.

NFPA 101®, *Life Safety Code®*, 2015 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2013 edition.

NFPA 120, *Standard for Fire Prevention and Control in Coal Mines*, 2015 edition.

NFPA 204, *Standard for Smoke and Heat Venting*, 2015 edition.

NFPA 214, *Standard on Water-Cooling Towers*, 2011 edition.

NFPA 220, *Standard on Types of Building Construction*, 2015 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*, 2013 edition.

NFPA 252, *Standard Methods of Fire Tests of Door Assemblies*, 2012 edition.

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*, 2015 edition.

NFPA 257, *Standard on Fire Test for Window and Glass Block Assemblies*, 2012 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 2013 edition.

NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 2012 edition.

NFPA 501A, *Standard for Fire Safety Criteria for Manufactured Home Installations, Sites, and Communities*, 2013 edition.

NFPA 600, *Standard on Facility Fire Brigades*, 2015 edition.

NFPA 601, *Standard for Security Services in Fire Loss Prevention*, 2015 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2013 edition.

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, 2012 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*, 2015 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2012 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2015 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2014 edition.

NFPA 805, *Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants*, 2015 edition.

NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Systems*, 2015 edition.

NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting*, 2012 edition.

NFPA 1143, *Standard for Wildland Fire Management*, 2014 edition.

NFPA 1144, *Standard for Reducing Structure Ignition Hazards from Wildland Fire*, 2013 edition.

NFPA 1221, *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems*, 2013 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus*, 2009 edition.

NFPA 1962, *Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances*, 2013 edition.

NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*, 2013 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2015 edition.

NFPA 2010, *Standard for Fixed Aerosol Fire-Extinguishing Systems*, 2015 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2015 edition.

NFPA *Fire Protection Handbook*, 2008, 20th edition.

SFPE *Engineering Guide to Fire Risk Assessment*, 2006 edition.

SFPE *Handbook of Fire Protection Engineering*, 2008, 4th edition.

2.3 Other Publications.

2.3.1 ANSI Publications. 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 API Publications. American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005-4070.

API 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division I and Division II*, 2012.

API 505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0 and Zone 2*, 2002.

API 537, *Flare Details for General Refinery and Petrochemical Service*, 2008.

API 2218, *Fireproofing Practices in Petroleum and Petrochemical Processing Plants*, 2010.

API RP 521, *Guide for Pressure Relieving and Depressurizing Systems*, 2007.

API RP 941, *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants*, 2008.

2.3.3 ASME Publications. American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ASME B31.1, *Power Piping*, 2012.

ASME B31.3, *Process Piping*, 2012.

ASME B31.8, *Gas Transmission and Distribution Piping Systems*, 2010.

2.3.4 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester*, 2012b.

ASTM D448, *Standard Classification for Sizes of Aggregate for Road and Bridge Construction*, 2012.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2012c.

ASTM E108, *Standard Test Methods for Fire Tests of Roof Coverings*, 2011.

ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, 2012.

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 2012.

ASTM E814, *Standard Test Method for Fire Tests of Penetration Firestop Systems*, 2011.

ASTM E1248, *Standard Practice for Shredder Explosion Protection*, 2009.

ASTM SI 10, *American National Standard for Metric Practice*, 2010.

2.3.5 IEC Publications. International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland.

IEC 62305, *Protection Against Lightning*, 2003.

2.3.6 IEEE Publications. IEEE, Three Park Avenue, 17th Floor, New York, NY 10016-5997.

IEEE C37.20.7, *Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults*, 2007.

IEEE 484, *Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications*, 2002.

IEEE 634, *Standard for Cable-Penetration Fire Stop Qualification Test*, 2004.

IEEE 1202, *Standard for Flame-Propagation Testing of Wire and Cable*, 2006.

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

ANSI/UL 263, *Standard for Fire Tests of Building Construction and Materials*, 2011.

ANSI/UL 723, *Test for Surface Burning Characteristics of Building Materials*, 2008, revised 2010.

ANSI/UL 790, *Tests for Fire Resistance of Roof Covering Materials*, 2004, revised 2008.

ANSI/UL 900, *Standard for Safety Test Performance of Air Filters*, 2004, revised 2011.

ANSI/UL 1479, *Standard for Fire Tests of Through-Penetration Firestops*, 2003, revised 2010.

ANSI/UL 1709, *Standard for Rapid Rise Fire Tests of Protection Materials for Structural Steel*, 2011.

2.3.8 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

OSHA 29 CFR 1910.146, "Permit Required Confined Space Standard," U.S. Department of Labor, 2010.

Title 29, CFR, Part 1910.156, "Fire Brigades," 2008.

2.3.9 Other Publications. Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Recommendations Sections.

NFPA 30, *Flammable and Combustible Liquids Code*, 2015 edition.

NFPA 101®, *Life Safety Code*®, 2015 edition.

NFPA 220, *Standard on Types of Building Construction*, 2015 edition.

NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, 2014 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2015 edition.



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. Capable of undergoing combustion.

3.3.4 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.

3.3.5 Compressed Air Foam (CAF). A homogenous foam produced by the combination of water, foam concentrate, and air or nitrogen under pressure.

3.3.6 Fast Depressurization System. A passive mechanical system designed to depressurize the transformer a few milliseconds after the occurrence of an electrical fault.

3.3.7 Fire Area. An area that is physically separated from other areas by space, barriers, walls, or other means in order to contain fire within that area.

3.3.8 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, 2015]

3.3.9 Fire Loading. The amount of combustibles present in a given area, expressed in Btu/ft² (kJ/m²).

3.3.10 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 D92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester*. [30, 2015]

3.3.11 Fire Prevention. Measures directed toward avoiding the inception of fire. [801, 2014]

3.3.12 Fire Protection. Methods of providing for fire control or fire extinguishment. [801, 2014]

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

3.3.14 Fire Risk Evaluation. An evaluation 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.

3.3.15 Fluid.

3.3.15.1 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.

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

3.3.16 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.

3.3.17 High Voltage Direct Current (HVDC) Converter Station. A facility that functions as an electrical rectifier (ac-dc) or an inverter (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.

3.3.18 Interior Finish. The exposed surfaces of walls, ceilings, and floors within buildings. [5000, 2015]

3.3.18.1 Class A Interior Finish. Materials having a flame spread index of 0–25, and a smoke developed index of

0–450 when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Test for 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.

3.3.18.2 Class B Interior Finish. Materials having a flame spread index of 26–75, and a smoke developed index of 0–450 when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Test for Surface Burning Characteristics of Building Materials*. Includes any material with a flame spread index of 26 or more but not more than 75 and with a smoke developed index of 450 or less.

3.3.19 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 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.)

3.3.20 Liquid.

3.3.20.1 Combustible Liquid. Any liquid that has a closed-cup flash point at or above 100°F (37.8°C). (See NFPA 30.)

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

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

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

3.3.21 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.

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

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

3.3.24 Rating.

3.3.24.1 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 and NFPA 257 as applicable.

3.3.24.2 Fire Resistance Rating. The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as determined by the tests, or methods based on tests, as prescribed in NFPA 5000. [5000, 2015]

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

3.3.26 Stakeholder. An individual, a group of individuals, or an organization that is perceived to affect or be affected by the fire hazards associated with the facility being evaluated. Stakeholders include all those who have a financial, personnel safety, public safety, or regulatory interest in the fire risk, such as the public (e.g., neighbors, community groups, first responders), employees, owner/investor(s), operator, insurer, regulator(s), and design team.

Chapter 4 Fire Protection Design Process

4.1 General.

4.1.1 The fire protection design process should be initiated under the direction of someone experienced in the area of fire protection engineering and having extensive knowledge and experience in power plant operation of the type of plant under consideration.

4.1.2 The creation of the fire protection design basis should be initiated as early in the plant 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 consideration regarding design, layout, and anticipated operating requirements.

4.1.3 Applicable process safety management (PSM) techniques should be considered.

4.1.4 The purpose of the Fire Protection Design Basis Document (DBD) is to provide a record of the decision-making process in determining the fire prevention and fire protection for specific hazards.

4.1.5 The Fire Protection Design Basis Document should be a living document that continues to evolve, as the plant design is refined, and it should be maintained and revised for the life of the plant. The Fire Protection Design Basis Document is key to the management of change process (see 17.4.3).

4.2 Stakeholders.

4.2.1 The stakeholders with an interest in the scope and applicability of the fire protection design should be identified early in the process.

4.2.2 Stakeholders establish goals and objectives and evaluate whether the recommendations of NFPA 850 are adequate to meet those goals and objectives. The criteria for acceptability of the level of fire protection should consider the perspective of the various stakeholders.



4.3 Inputs to the Design Process.

4.3.1 General Inputs. In addition to the guidelines in this document, the following list should be reviewed for applicability:

- (1) Codes
 - (a) Building codes — state and local
 - (b) Fire codes — state and local
- (2) Standards
 - (a) Industry standards
 - (b) Utility company standards
 - (c) Insurance requirements
 - (d) Applicable NFPA documents (*See Chapter 2.*)
- (3) Regulations
 - (a) Environmental
 - (b) OSHA
- (4) Other references
 - (a) *SFPE Handbook of Fire Protection Engineering* and journals
 - (b) *SFPE Engineering Guide to Fire Risk Assessment* (Chapters 14 and 15)
 - (c) Best Practices: EEI, EPRI, IEEE
 - (d) *NFPA Fire Protection Handbook*
 - (e) NFPA 805 (Performance-Based Criteria in Chapter 4)
- (5) Design documents
- (6) Stakeholder inputs

4.3.2 Project-Specific Inputs. Each facility will have its own special conditions that impact on the nature of the installation. Many of the specific criteria herein might require modification, due to the consideration of all project-specific factors involved. The project-specific inputs utilized in the design basis process include but are not limited to the following:

- (1) Base load/peaking unit
- (2) Personnel levels
 - (a) Unattended
 - (b) Low level of occupancy
 - (c) High level of occupancy
- (3) Fuel types and volatility
- (4) Plant layout and geographic location
- (5) Equipment availability/redundancy
- (6) Availability of water supply
- (7) Capability of emergency responders
- (8) Storage configuration (short term and long term)
- (9) Historical loss information/lessons learned/fire reports (*See Annex B and Annex D.*)

4.4 Fire Protection Design Basis Process.

4.4.1 Stakeholder establishes goals and objectives and evaluates whether the recommendations of NFPA 850 are adequate to meet those goals and objectives. The criteria for acceptability of the level of fire protection should consider the perspective of the various stakeholders.

4.4.2 The general arrangement and plant layout should be provided to clearly reflect the separation of hazards. If layout is not acceptable, a fire risk evaluation should be developed to ensure objectives are met, and then return to the review process.

4.4.3 Each hazard/area is reviewed against the goals and objectives and NFPA 850. If the hazards control is not acceptable, then a fire risk evaluation should be developed to ensure objectives are met, and then return to the review process.

4.4.4 A DBD is developed.

4.4.5 As the project evolves, the DBD should be reviewed and updated as necessary to incorporate changes and revisions. (*See Figure 4.4.5.*)

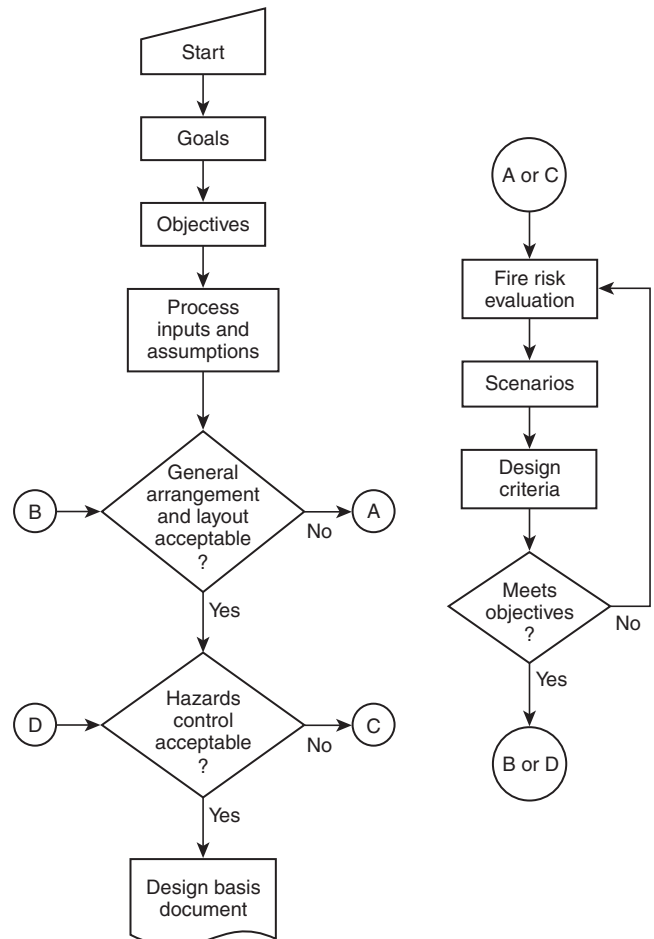


FIGURE 4.4.5 Fire Protection Design Basis Process Flow Chart.

4.5 Fire Protection Design Basis Document (Deliverables).

4.5.1 The scope of the DBD is to establish the fire protection design criteria for the facility. The development of the DBD will be an iterative process. The DBD will be revised as the design progresses, based on dialogue among the stakeholders. The DBD should outline the fire protection/prevention design basis for achieving the fire hazard control objectives agreed upon by the stakeholders, including the following:

- (1) Identify assumptions (including items in 4.3.2).
- (2) Identify source documents.
- (3) Identify each hazard, identify which fire prevention/protection features are to be provided or omitted, and summarize the decision-making process.
- (4) Identify where operational and administrative controls are assumed to be in place to mitigate the need for fire protection features.

4.5.2 During the various stages of the design development and the development of the DBD, assumptions will be made when inadequate or insufficient information is available. These assumptions should be clearly identified and documented in accordance with Section 4.5. As additional information becomes available, the assumptions should be updated or replaced with actual design information and the DBD should be amended as necessary to reflect the more definitive information.

4.5.3 The process identified in 4.5.1 and 4.5.2 should be documented. The format of the document is a statement on general fire protection philosophy for the facility and a comparison of the facility fire protection features to the guidelines in the design chapters; for example, protection of oil hazards and also addressing containment and drainage. A sample table of contents for the DBD is contained in Annex E.

Chapter 5 General Plant Design

5.1 Plant Arrangement.

5.1.1 Fire Area Determination.

5.1.1.1 The electric generating plant and the high voltage direct current converter station should be subdivided into separate fire areas as determined by the Fire Protection Design Basis Document 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.

5.1.1.2 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

5.1.1.3* Unless consideration of the factors of 5.1.1.2 indicates otherwise or if adequate spatial separation is provided as permitted in 5.1.1.5, it is recommended that fire area boundaries be provided to separate the following:

- (1) Cable spreading room(s), and cable tunnel(s) and high voltage lead shafts 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 a switchgear room or relay room, from adjacent areas
- (4) Battery rooms from associated battery chargers, equipment, and 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 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, supervisory control and data acquisition (SCADA) rooms, and remote terminal unit (RTU) rooms from adjacent areas
- (15) Adjacent turbine generators beneath the underside of the operating floor
- (16) Between the boiler house and the areas of the coal handling system above the bin, bunker, or silo
- (17) Fan rooms and plenum chambers from adjacent areas [fire dampers might not be advisable in emergency ventilation ducts (*see Section 5.4*)]
- (18) Switchgear area and sulfur hexafluoride (SF₆) switchyard area from adjacent areas

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

5.1.1.5 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 evaluation.

5.1.2 Openings in Fire Barriers.

5.1.2.1* 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 E814, *Standard Test Method for Fire Tests of Penetration Firestop Systems*. 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.

5.1.2.2 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.*)

5.1.3 Hydrogen Storage. Hydrogen storage facilities should be separated from adjacent areas. (*See NFPA 55.*)

5.1.4 Outdoor Oil-Insulated Transformers.

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

5.1.4.2 Determination of the type of physical separation to be used between transformers, control equipment, and building structures should be based on a detailed analysis 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) Type and amount of exposed equipment, including high line structures, motor control center (MCC) equipment, breakers, other transformers, and so forth.
- (5) Power rating of the transformer
- (6) Fire suppression systems provided
- (7) Type of electrical protective relaying provided



- (8) Availability of replacement transformers (long lead times)
 (9)*The existence of fast depressurization systems

Once this analysis has been completed, any decisions made as a result should be included as part of the Fire Protection Design Basis Document.

5.1.4.3* Unless consideration of the factors in 5.1.4.2 indicates otherwise, it is recommended that any oil-insulated transformer containing 500 gal (1893 L) or more of oil be separated from adjacent structures by a 2-hour-rated firewall or by spatial separation in accordance with Table 5.1.4.3. Where a firewall is provided between structures and a transformer, it should extend vertically and horizontally as indicated in Figure 5.1.4.3.

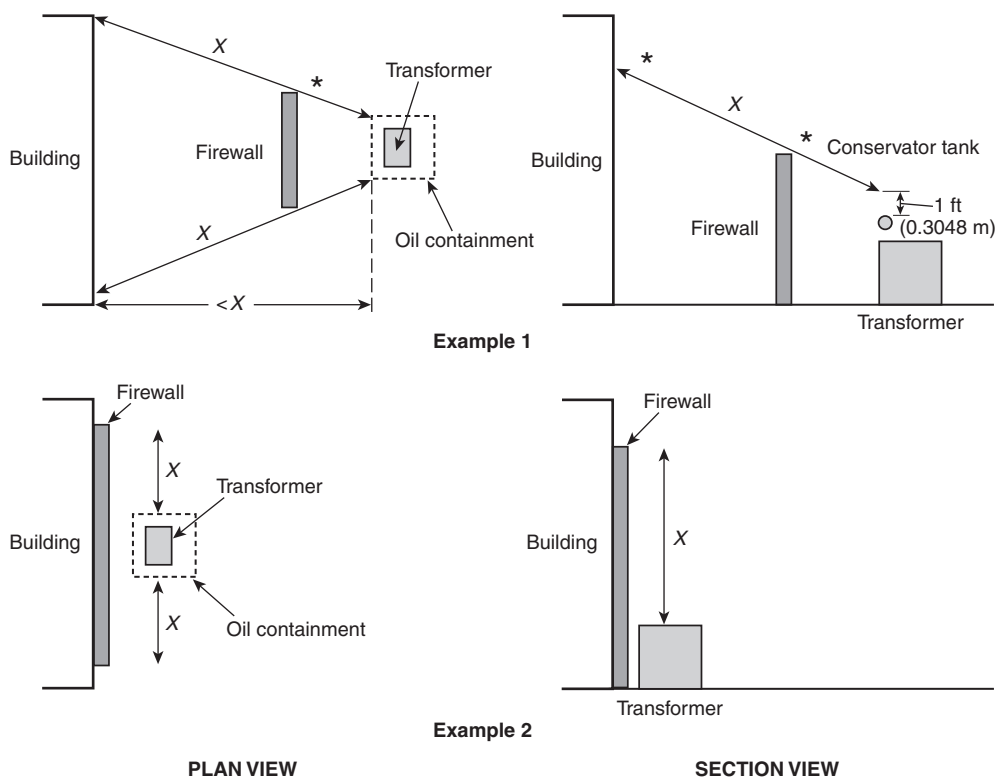
Table 5.1.4.3 Outdoor Oil-Insulated Transformer Separation Criteria

Transformer Oil Capacity		Minimum (Line-of-Sight) Separation Without Firewall	
gal	L	ft	m
<500	<1893	See 5.1.4.2	
500–5000	1893–18,925	25	7.6
>5000	>18,925	50	15

5.1.4.4 Unless consideration of the factors in 5.1.4.2 indicates otherwise, it is recommended that adjacent oil-insulated transformers containing 500 gal (1893 L) or more of oil be separated from each other by a 2-hour-rated firewall or by spatial separation in accordance with Table 5.1.4.3. When the oil containment, as shown in Figure 5.1.4.4, consists of a large, flat concrete containment area that holds several transformers and other equipment in it without the typical pit containment areas, specific containment features to keep the oil in one transformer from migrating to any other transformer or equipment should be provided. Subsection 5.5.7 can be used for guidance. 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, or to the edge of the containment area, whichever is greater. (See Figure 5.1.4.4 for an illustration of the recommended dimensions for a firewall.)

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

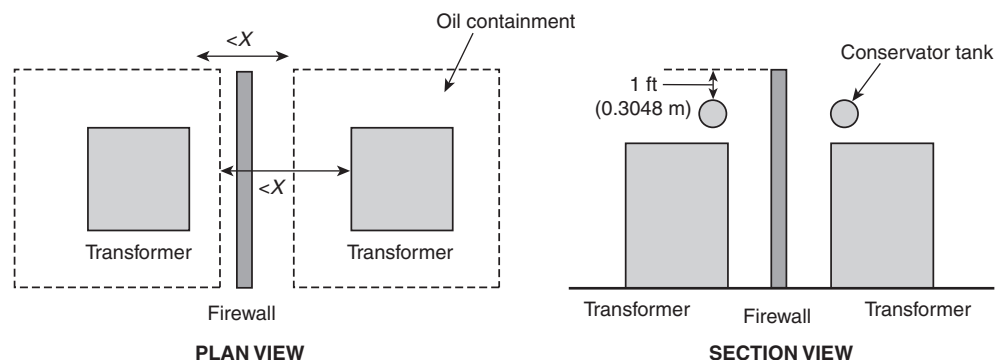
5.1.4.6 For transformers with less than 500 gal (1893 L) of oil and where a firewall is not provided, the edge of the postulated oil spill (i.e., containment basin, if provided) should be separated by a minimum of 5 ft (1.5 m) from the exposed structure to prevent direct flame impingement on the structure.



X: Minimum separation distance from Table 5.1.4.3.

*: See A.5.1.4.3.

FIGURE 5.1.4.3 Illustration of Oil-Insulated Transformer Separation Recommendations.



X: Minimum separation distance from Table 5.1.4.3.

FIGURE 5.1.4.4 Outdoor Oil-Insulated Transformer Separation Criteria.

5.1.4.7 Outdoor transformers insulated with a less flammable liquid should be separated from each other and from adjacent structures that are critical to power generation by firewalls or spatial separation based on consideration of the factors in 5.1.4.2 and 5.1.4.5.

5.1.5 Indoor Transformers.

5.1.5.1 Dry-type transformers are preferred for indoor installations.

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

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

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

5.1.6 General Substation Arrangement.

5.2 Life Safety.

5.2.1 For life safety considerations for electric generating plants included in the scope of this document, see NFPA 101.

5.2.2* Structures should be classified as follows, as defined in NFPA 101:

- (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. Temporary occupancies and means of egress inside the structures and piers of large "bulb" hydroelectric units should be evaluated based on 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.

5.2.3 In the event of a plant fire, egress of occupants in control facilities can be delayed due to emergency shutdown procedures. (See NFPA 101, 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.

5.2.4 In the event of a plant fire, explosion, or other incident that would require evacuation of a turbine hall or boiler house (or any other occupied area) during an outage, evacuation plans and emergency plans in general should be developed that would take into consideration the increased occupancy load in these areas.

5.3 Building Construction Materials.

5.3.1 Construction materials being considered for electric generating plants and high-voltage direct current converter stations should be selected based on the Fire Protection Design Basis Document and on consideration of the following standards:

- (1) NFPA 220, *Standard on Types of Building Construction*
- (2) ASTM E119 or ANSI/UL 263, *Standard Test Methods for Fire Tests 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 259, *Standard Test Method for Potential Heat of Building Materials*
- (5) ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Test for Surface Burning Characteristics of Building Materials*

5.3.2 Construction materials used in the boiler, engine, or turbine-generator buildings or other buildings critical to power generation or conversion should meet the definition of *noncombustible* or *limited combustible*, except for the following:

- (1) Roof coverings, which should be as outlined in 5.3.4
- (2) Limited use of translucent reinforced plastic panels as allowed by the Fire Protection Design Basis Document

5.3.3 The use of material that does not meet the definition of *noncombustible* or *limited combustible*, such as translucent reinforced plastic panels, is permitted in limited applications if the Fire Protection Design Basis Document and/or fire risk evaluation demonstrate that the material is acceptable.

5.3.4 Roof covering should be Class A in accordance with ASTM E108, *Standard Test Methods for Fire Tests of Roof Coverings*, or UL 790, *Tests for Fire Resistance of Roof Covering Materials*.



Metal roof deck construction, where used, should be “Class I” or “fire classified.”

5.3.5 Interior Finish.

5.3.5.1 Cellular or foamed plastic materials (as defined in Annex A of NFPA 101) should not be used as interior finish.

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

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

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

5.4.1 Smoke and Heat Venting.

5.4.1.1 General.

5.4.1.1.1 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.

5.4.1.1.2 Smoke and heat vents should not be left open where they can sustain damage from high wind conditions.

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

5.4.1.2 Heat Vents.

5.4.1.2.1 Heat vents should be provided for areas identified by the Fire Protection Design Basis Document. Where heat vents are provided, heat generated under fire conditions should be vented from its place of origin directly to the outdoors.

5.4.1.2.2 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.)

5.4.1.3 Smoke Vents.

5.4.1.3.1 Smoke venting should be provided for areas identified by the Fire Protection Design Basis Document. 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.

5.4.1.3.2* Separate smoke management or 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, NFPA 92, and NFPA 204.) Smoke venting also is permitted to be accomplished through the use of portable smoke ejectors. A smoke management system should be utilized to mitigate the effects of smoke and heat during the early stages of a fire.

5.4.1.3.3 Consideration should be given to smoke venting for the following areas: control room, cable spreading room(s), switchgear room, and sensitive electronic equipment rooms.

5.4.1.3.4 In the areas with gaseous fire extinguishing systems, the smoke ventilation system should be properly interlocked to ensure the effective operation of the gaseous fire extinguishing system.

5.4.1.3.5 Smoke removal system dampers, where installed, normally are operable only from an area immediately outside

of, or immediately within, the fire area served since it is desired to have entry into, and inspection of, the fire area by fire-fighting personnel prior to restoring mechanical ventilation to the fire area. Smoke removal system dampers 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.

5.4.1.3.6 The fan power supply wiring and controls for smoke exhaust should be located external to the fire area served by the fan or be installed in accordance with the Fire Protection Design Basis Document.

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

5.4.2.1 For normal heating, ventilating, and air-conditioning systems, see NFPA 90A or NFPA 90B as appropriate.

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

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

5.4.2.4 Fire dampers (doors) compatible with the rating of the barrier should be provided at the duct penetrations in accordance with NFPA 90A 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 5.1).

5.4.2.5 Smoke dampers, where installed, should be installed in accordance with NFPA 90A.

5.4.2.6 The fresh air supply intakes to all areas should either be located so as to minimize the possibility of drawing products of combustion into the plant, or be provided with automatic closure on detection of smoke. Separation from exhaust air outlets, smoke vents from other areas, and outdoor fire hazards should all be considered.

5.5 Containment and Drainage.

5.5.1* 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.) 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

5.5.2* 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

Independent of the above, the drainage systems should consider the maximum water introduced by the wash-down sys-

tems. If this amount exceeds the drainage required for fire protection, it should govern the sizing of the drainage system. Additional precautions should be taken for belowgrade areas to prevent damage of equipment due to water buildup.

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

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

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

5.5.6 Drainage facilities should be provided for outdoor oil-insulated transformers, or the ground should be sloped such that oil spills will flow away from buildings, structures, and adjacent transformers. Unless drainage from oil spills is accommodated by sloping the ground around transformers away from structures or adjacent equipment, consideration should be given to providing curbed areas or pits around transformers. The pit or drain system or both should be sized in accordance with 5.5.2. If a layer of uniformly graded stone is provided in the bottom of the curbed area or pit as a means of minimizing ground fires, the following should be addressed:

- (1) Sizing of the pit should allow for the volume of the stone, keeping the highest level of oil below the top 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.

5.5.6.1 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.

5.5.6.2 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-ft² (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*).

5.5.7 For facilities consisting of more than one generating unit that are not separated by a fire barrier [see 5.1.1.3(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.

5.5.8 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).

5.6 Emergency Lighting.

5.6.1 Emergency lighting should be provided for means of egress. (See NFPA 101.)

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

5.7 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.

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 all of the following:

- (1) Either of the following, whichever is greater:
 - (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 underfloor 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 5.1.4]
- (2) The hose stream demand of not less than 500 gpm (1893 L/min)
- (3) Incidental water usage for non-fire protection purposes

6.2.2* At least one reliable water supply should be provided. The Fire Protection Design Basis Document should identify the need for multiple supply 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 a loss in terms of property and generation

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



6.2.3 Each water supply should be connected to the station supply main or yard main by separate connections arranged and valve controlled to minimize the possibility of multiple supplies being impaired simultaneously.

6.2.3.1 If a single water supply is utilized, two independent connections should be provided. If a situation can arise in which the primary water supply can become unavailable (e.g., dewatering of penstocks), an auxiliary supply should be provided. Each supply should be capable of meeting the recommendations in 6.2.2.

6.2.4 Consideration of water quality can prevent long-term problems relating to fire protection water supply. For example, in some rivers and tributaries the existence of microorganisms limits the use of raw water for fire protection without treatment. 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 Protection Design Basis Document, 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. The manual shutdown should be at the pump controllers only.

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.)

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 17) 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 Supply Mains, Yard Mains, Hydrants, and Building Standpipes.

6.4.1 Supply Mains, Yard Mains, and Hydrants.

6.4.1.1 Supply mains, yard mains, and outdoor fire hydrants should be installed on the plant site. (See NFPA 24.) 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.

6.4.1.7 It might be necessary for the fire department to draft from a body of water adjacent to the plant. However, the terrain and elevation above the water supply can make it difficult for drafting. Consideration should be given to installing a dry hydrant with adequate fire apparatus access.

6.4.2 Standpipe and Hose Systems.

6.4.2.1 Standpipe and hose systems should be installed in buildings and structures where deemed necessary by the Fire Protection Design Basis. (See NFPA 14.) 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 determined by a Fire Protection Design Basis. (See NFPA 14.)

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. For first aid fire protection, suitable fire extinguishers should be provided. (See NFPA 10.)

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 through 15 or as determined by the Fire Protection Design Basis Document. Fixed suppression systems should be designed in accordance with the following codes and standards unless specifically noted otherwise:

- (1) NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*
- (2) NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*
- (3) NFPA 13, *Standard for the Installation of Sprinkler Systems*
- (4) NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*
- (5) NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*
- (6) NFPA 17, *Standard for Dry Chemical Extinguishing Systems*
- (7) NFPA 750, *Standard on Water Mist Fire Protection Systems*
- (8) NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*
- (9) NFPA 2010, *Standard for Aerosol 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

Personnel hazards created by the discharge of CO₂ should be considered in the design of the system. The design should take into account the immediate release of CO₂ into the protected area and the possibility of CO₂ leakage, migration, and settling into adjacent areas and lower elevations of the plant. See NFPA 12 for hazards to personnel. At a minimum, if CO₂ systems are provided, they should be provided with an odorizer for alerting personnel, and breathing apparatus should be provided for operators in areas that cannot be abandoned.

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 affect 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. (See NFPA 12.)

6.6.3.4.1 Evacuation of a protected area is recommended before any special extinguishing system discharges.

6.6.3.4.2 Alarm systems that are audible above machinery background noise or that are visual or olfactory or a combination should be used where appropriate.

6.6.3.4.3 Personnel warning signs should be used as necessary.

6.6.3.4.4 Retroactive requirements for enhancing the safety of existing CO₂ systems are detailed in NFPA 12 paragraphs 4.3.2 (safety signs), 4.3.3.6 and 4.3.6.6.1 (lockout valves), and 4.5.6.1 (pneumatic time delays and pneumatic predischARGE alarms).

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 Protection Design Basis Document 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.)

6.7.2 Automatic fire detectors should be installed in accordance with NFPA 72.

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 Protection Design Basis Document.
- (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 Protection Design Basis Document. This chapter identifies fire and explosion hazards in fossil fueled electric generating stations and specifies the recommended protection criteria unless the Fire Protection Design Basis Document 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 could 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, NFPA 55, NFPA 56, NFPA 58, and ASME B31.1, *Power Piping*.

7.2.2 The plant's fuel gas shutoff valve should be located in a remote area and accessible under emergency conditions. 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* and ANSI C2, *National Electrical Safety Code*.

7.2.4* Inerting. Prior to introducing fuel gas to, or removing fuel gas from, the fuel gas piping, inerting should be performed.

7.2.5* Maintenance, Modification, and Repair. The hazards associated with flammable gases, including those hazards arising from toxic constituents in the gas and asphyxiants, should be considered when performing maintenance, modifications, or repairs.

7.2.5.1 Fuel gas piping should be inerted in accordance with 7.2.4 prior to maintenance, modifications, or repair.

7.2.5.2 When performing maintenance, modification, or repair of piping that contains a flammable gas that has toxic constituents, or when inerting fuel gas piping with asphyxiants, the area should be ventilated or considered a confined space as regulated by U.S. Department of Labor, OSHA 29 CFR 1910.146, "Permit Required Confined Space Standard."

7.3 Fuel Handling — Oil.

7.3.1 Fuel oil storage, pumping facilities, and associated piping should comply with NFPA 30, NFPA 31, 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, Articles 500 and 501 of *NFPA 70*, 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 ft² of floor area (0.30 m³/min/m²), but not less than 150 ft³/min (0.071 m³/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, compressed air foam systems, or gaseous total flooding system(s). Local application

dry chemical systems are permitted to be used in areas that normally do not have re-ignition 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 Protection Design Basis Document. The Fire Protection Design Basis Document 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. Where coal storage barns or domes are used to enclose storage piles, the design of the structure should include dedicated space to allow small vehicles to access all areas of the coal pile. The design should prevent stored coal from encroaching on the dedicated space.

7.4.1.3 Where coal storage barns or domes are used to enclose storage piles, the fire detection, fire protection, fire alarm, dust collection, dust suppression, explosion venting, and housekeeping recommendations contained herein for coal handling areas and structures should be considered. The plant-specific features provided for the coal barn/dome should be as determined during the Fire Protection Design Process Document. (See Chapter 4.)

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.)

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 fire-fighting 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. Spontaneous heating can be slowed by minimizing air flow through the bins by such means as inerting, filling the bins with high-expansion foam, or sealing the surface of the coal with an appropriate binder/sealer designed for this purpose.

7.4.2.4* During idle periods, flammable gas levels, CO levels, and temperatures should be monitored.

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 bin, bunker, or silo should be provided. This unloading process might take the form of conveyors discharging to a stacking out pile. Another method would be to 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. Proper preplanning should be developed to prevent a dust cloud, such as covering the coal with a blanket of high-expansion foam, water mist, water spray with fire-fighting additives, dust suppression, or dust collection.

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 fire-fighting additives such as Class A foams, penetrants, or wetting agents and water additives
- (2) Injection of inert gas
- (3) Emptying the silo through the feeder pipe to a safe location (inside or outside the powerhouse) and trucking away the debris

7.4.2.6.1 The following fire-fighting strategies should be taken into consideration:

- (1) Water has been used successfully 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 fire-fighting additives with water can be highly effective for coal fires, especially sub-bituminous coal fires. This use of fire-fighting additives 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.

7.4.2.9 It might not be practical to install explosion vents on a coal bin, bunker, and silo. Typical silo designs do not have sufficient area above the coal level for properly designed explosion vents. Vents would present an exposure hazard to any personnel in adjacent areas (*see NFPA 654*.) If explosion vents are considered, they should be designed in accordance with NFPA 68.

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
- (5) Routine cleaning of coal handling areas

The frequency of cleaning activities is plant specific based on re-fueling activities, type of coal, space construction features, et cetera. Dust accumulation on overhead beams and joists contributes significantly to the secondary dust cloud. Other surfaces, such as the tops of ducts and large equipment, can also contribute significantly to the dust cloud potential. Due consideration should be given to dust that adheres to walls, since it is easily dislodged. Attention and consideration should also be given to other projections such as light fixtures, which can provide surfaces for dust accumulation.

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, surfactants, binders, or a combination of these 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 and at stack-out points.

7.4.3.4 Dust collectors should be located outside. For dust collection systems provided for handling combustible dusts,



see NFPA 654. 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. Explosion suppression systems are permitted to be provided for dust collection systems that cannot be safely vented to the outside. (*See NFPA 69.*)
- (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) Dust collectors should not discharge into inactive coal storage bins, bunkers, or silos.
- (5) High-level detection with an annunciator alarm should be provided for the dust hoppers.
- (6) Monitoring and trending for carbon monoxide should be provided for dust collectors to detect spontaneous combustion.

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.

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.*) 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 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.*)

7.4.6 Fire Protection.

7.4.6.1 Automatic sprinkler or water spray fixed systems should be provided for coal handling structures that are critical to power generation and subject to accumulations of coal or coal dust. Automatic sprinkler systems should be designed for a minimum of 0.25 gpm/ft² (10.2 mm/min) density over a 2500 ft² (232 m²) area. If water spray fixed systems are used to protect structures, the same densities should be used.

7.4.6.2* Automatic sprinkler or water spray fixed systems should be provided for coal conveyors that are critical to continuous power generation. System coverage should include transfer points (tail dust hoods and head chutes). Sprinklers should be designed for a minimum of 0.25 gpm/ft² (10.2 mm/min) density over 2000 ft² (186 m²) of enclosed area or the most remote 100 linear ft (30 m) of conveyor structure up to 2000 ft² (186 m²). For water spray design criteria, see NFPA 15. Water spray systems should be considered for enclosed conveyors that are inclined because of the greater potential for rapid fire spread.

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. See NFPA 15. The conveyor width and other sprinkler obstructions should be considered in protection of the return belt and other floor level equipment. See NFPA 13 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 Protection Design Basis Document. Draft barriers will improve 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/ft² (8.1 mm/min) over the projected plan area of the dust collector. Use of fire-fighting additives should be considered for sub-bituminous 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.
- (4) Are critical to plant operation.

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

7.4.6.6 Consideration should be given to providing detection-only systems on non-critical conveyors to facilitate a manual response.

7.5 Steam Generator. For boiler-furnaces, see NFPA 85.

7.5.1 Fire Protection.

7.5.1.1 Boiler-furnaces with multiple oil-fired burners or that use oil for ignition should be protected with automatic sprinkler, water spray, foam, foam-water sprinkler systems, or compressed air foam 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 igniters and adjacent fuel oil piping and cable a 20 ft (6.1 m) distance from the burner and igniter, 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/ft² (10.2 mm/min) over the protected area. Compressed air foam systems should be designed and installed in accordance with NFPA 11 and their listing for the specific hazards and protection objectives specified in the listing.

7.5.2 Pulverizers.

7.5.2.1 For pulverized fuel systems, see NFPA 85.

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.

7.5.2.3 Pulverizer explosion mitigation methods to consider include inerting and temperature control.

7.5.2.4 Personnel warning systems should be considered during pulverizer startup, shutdown, and trip.

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 5.5.

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/ft² (10.2 mm/min) over the oil containment equipment surface. Water spray systems should be designed for 0.25 gpm/ft² (10.2 mm/min) for a minimum 20 ft (6.1 m) from the hazard. Compressed air foam systems should be designed and installed in accordance with NFPA 11 and their listing for the specific hazards and protection objectives specified in the listing. Combustible oil hazards associated with forced and induced draft fans driven with steam turbines should be protected with automatic sprinkler, water spray, foam-water sprinkler systems, or compressed air foam 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 (control valve should be easily accessible) 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 density of 0.60 gpm/ft² (24.4 mm/min) is recommended. Where the rotor or stator is vertical, water spray should be applied to both sides to obtain adequate penetration. A minimum density of 0.30 gpm/ft² (12.2 mm/min) 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/ft² (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 stand-pipe 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/ft² (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/ft² (10.2 mm/min) over 3500 ft² (325 m²). 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 5.1.4 and 5.1.5.)

7.6.5* Scrubbers, Scrubber Buildings, and Exhaust Ducts.

7.6.5.1 General. Scrubbers are the main component for flue gas desulfurization (FGD) processes, which are frequently used to maintain low sulfur emissions. Auxiliary equipment associated with the FGD process is often enclosed in scrubber buildings constructed around the lower elevations of the scrubber. Some scrubbers are entirely enclosed in the scrubber building as well. Exhaust ducts provide a flow path from the scrubber outlet to the stack. 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 was extensive smoke and heat damage to the building. Fires can also occur in ductwork.

7.6.5.2 Scrubber Buildings.

7.6.5.2.1 Buildings should be constructed of materials meeting the criteria outlined in Section 5.3.

7.6.5.2.2 Where scrubbers have combustible 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/ft² (8.1 mm/min). The area of operation should be the area of the building or 10,000 ft² (930 m²). 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 ft² (0.09 m²) per 50 ft² (4.6 m²) 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. All equipment lined with combustible material should be identified with warning signs or placards.

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. See also NFPA 51B. At a minimum, strict work 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) The scrubber reservoir should be maintained full if possible or returned to service as quickly as possible during an outage.
- (3) 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 hot 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.

