

NFPA®

850

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

2020



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NFPA® 850

Recommended Practice for

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

2020 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 4, 2019, with an effective date of November 24, 2019, and supersedes all previous editions.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See “Codes & Standards” at www.nfpa.org for more information.

This edition of NFPA 850 was approved as an American National Standard on November 24, 2019.

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 underwent 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 were added. Recommendations for active carbon injection systems were added to Chapter 7, and Chapter 11 was expanded to provide recommendations for fire and life safety involving photoelectric solar power plants.

The 2020 edition of NFPA 850 has undergone a complete reorganization. Information is now grouped in a more logical layout that helps users navigate the document more quickly. New chapters on flywheel energy systems and compressed air energy storage (CAES) have been added to address technologies used in the industry.

Technical Committee on Electric Generating Plants

Mark S. Boone, *Chair*
Dominion Energy, VA [U]

Steven M. Behrens, AXA XL Risk Consulting/ Global Asset Protection Services, LLC, CT [I]
Daryl C. Bessa, F. E. Moran, Inc. Special Hazard Systems, IL [IM]
Donald C. Birchler, FP&C Consultants, MO [SE]
James Casey, Marsh Risk Consulting, OH [I]
Stanley J. Chingo, NISYS Corporation, GA [SE]
Tom V. Clark, AEGIS Insurance Services, Inc., NJ [I]
Larry M. Danner, GE Power & Water, SC [M]
Russell A. Deubler, HSB Professional Loss Control, NH [I]
Laurie B. Florence, UL LLC, IL [RT]
Brian T. Ford, Tennessee Valley Authority, TN [U]
Ismail M. Gosla, Fluor Corporation, CA [SE]
Daniel D. Groff, AIG Energy and Engineered Risk, PA [I]
Paul Hayes, American Fire Technologies, NC [IM]
Fred L. Hildebrandt, Amerex/Janus Fire Systems, IN [M]
Rep. Fire Suppression Systems Association
Rickey L. Johnson, Liberty International Underwriters, NY [I]
David E. Kipley, JENSEN HUGHES, IL [SE]
Rep. JENSEN HUGHES

Clinton Marshall, FM Global, MA [I]
Rep. FM Global
Steve Maurer, Fuelcell Energy Inc., CT [M]
Joseph L. Navarra, Exelon Corporation/Pepco, DC [M]
Eric Prause, Doosan Fuel Cell America, CT [M]
Scot Pruett, Black & Veatch Corporation, KS [SE]
Karen I. Quackenbush, Fuel Cell & Hydrogen Energy Association, DC [M]
Ronald Rispoli, Entergy Corporation, AR [U]
Richard Ryan, Rodeo/Hercules Fire Protection District, CA [E]
Donald Struck, Siemens Fire Safety, NJ [M]
Rep. National Electrical Manufacturers Association
Leo Subbarao, Fire Department City of New York, NY [E]
Robert D. Taylor, PRB Coal Users Group, IN [U]
Robert Vincent, Shambaugh & Son, L.P., IN [IM]
Rep. National Fire Sprinkler Association

Alternates

James Bouche, F. E. Moran, Inc., IL [IM]
(Alt. to Daryl C. Bessa)
Larry Dix, Global Asset Protection Services, LLC, NY [I]
(Alt. to Steven M. Behrens)
Byron E. Ellis, Entergy Corporation, LA [U]
(Alt. to Ronald Rispoli)
William G. Gurry, Marsh Risk Consulting, CA [I]
(Alt. to James Casey)
Kelvin Hecht, Doosan Fuel Cell America, CT [M]
(Alt. to Eric Prause)
John Nathan Ihme, GE, SC [M]
(Alt. to Larry M. Danner)
Jay Keller, Fuel Cell And Hydrogen Association, CA [M]
(Alt. to Karen I. Quackenbush)
Regina M. Loschiavo, HSB Munich Re, NC [I]
(Alt. to Russell A. Deubler)
Dennis P. Mason, AEGIS Insurance Services, MI [I]
(Alt. to Tom V. Clark)

Timothy Pope, Amerex/Janus Fire Systems, IN [M]
(Alt. to Fred L. Hildebrandt)
Larry D. Shackelford, Southern Company, AL [U]
(Voting Alt.)
James H. Sharp, Siemens Energy, FL [M]
(Alt. to Donald Struck)
Blake M. Shugarman, UL LLC, IL [RT]
(Alt. to Laurie B. Florence)
Todd E. Stinchfield, FM Global, RI [I]
(Alt. to Clinton Marshall)
Andrew Wolfe, JENSEN HUGHES, MD [SE]
(Alt. to David E. Kipley)
Johnny Chung-Hin Young, Contra Costa County Fire District, CA [E]
(Alt. to Richard Ryan)

Nonvoting

Thomas C. Clayton, Overland Park, KS [SE]
(Member Emeritus)
Brian J. O'Connor, NFPA Staff Liaison

Leonard R. Hathaway, The Villages, FL [I]
(Member Emeritus)

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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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Information on referenced and extracted 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: Advanced light water reactor electric generating plants are addressed in NFPA 804; 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.

1.4.1 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.

1.4.2 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 SI10, *American National 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*, 2018 edition.
- NFPA 2, *Hydrogen Technologies Code*, 2020 edition.
- NFPA 10, *Standard for Portable Fire Extinguishers*, 2018 edition.
- NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2016 edition.
- NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2018 edition.
- NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 2018 edition.
- NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.
- NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.
- NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 edition.
- NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2019 edition.
- NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2017 edition.
- NFPA 18A, *Standard on Water Additives for Fire Control and Vapor Mitigation*, 2017 edition.
- NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.
- NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2018 edition.
- NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2019 edition.
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2020 edition.
- NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.
- NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, 2018 edition.
- NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 2020 edition.
- NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2018 edition.
- NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2019 edition.
- NFPA 54, *National Fuel Gas Code*, 2018 edition.
- NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2020 edition.
- NFPA 56, *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, 2020 edition.
- NFPA 58, *Liquefied Petroleum Gas Code*, 2020 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, 2019 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2019 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2019 edition.

NFPA 75, *Standard for the Fire Protection of Information Technology Equipment*, 2020 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 2019 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2019 edition.

NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, 2017 edition.

NFPA 85, *Boiler and Combustion Systems Hazards Code*, 2019 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2019 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2018 edition.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems*, 2018 edition.

NFPA 92, *Standard for Smoke Control Systems*, 2018 edition.

NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*, 2017 edition.

NFPA 101®, *Life Safety Code®*, 2018 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2019 edition.

NFPA 120, *Standard for Fire Prevention and Control in Coal Mines*, 2020 edition.

NFPA 204, *Standard for Smoke and Heat Venting*, 2018 edition.

NFPA 214, *Standard on Water-Cooling Towers*, 2016 edition.

NFPA 220, *Standard on Types of Building Construction*, 2018 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*, 2019 edition.

NFPA 252, *Standard Methods of Fire Tests of Door Assemblies*, 2017 edition.

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*, 2019 edition.

NFPA 257, *Standard on Fire Test for Window and Glass Block Assemblies*, 2017 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 2018 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*, 2017 edition.

NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 2017 edition.

NFPA 501A, *Standard for Fire Safety Criteria for Manufactured Home Installations, Sites, and Communities*, 2017 edition.

NFPA 600, *Standard on Facility Fire Brigades*, 2020 edition.

NFPA 601, *Standard for Security Services in Fire Loss Prevention*, 2020 edition.

NFPA 652, *Standard on the Fundamentals of Combustible Dust*, 2019 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2020 edition.

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, 2020 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*, 2019 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2017 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2019 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2020 edition.

NFPA 804, *Standard for Fire Protection for Advanced Light Water Reactor Electric Generating Plants*, 2020 edition.

NFPA 805, *Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants*, 2020 edition.

NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Systems*, 2020 edition.

NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting*, 2017 edition.

NFPA 1143, *Standard for Wildland Fire Management*, 2018 edition.

NFPA 1144, *Standard for Reducing Structure Ignition Hazards from Wildland Fire*, 2018 edition.

NFPA 1221, *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems*, 2019 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus*, 2016 edition.

NFPA 1962, *Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances*, 2018 edition.

NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*, 2018 edition.

NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*, 2019 edition.

NFPA 1982, *Standard on Personal Alert Safety Systems (PASS)*, 2018 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2018 edition.

NFPA 2010, *Standard for Fixed Aerosol Fire-Extinguishing Systems*, 2020 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2018 edition.

NFPA Fire Protection Handbook, 2008, 20th edition.

2.3 Other Publications.

2.3.1 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*, 2018.

API 537, *Flare Details for Petroleum, Petrochemical, and Natural Gas Industries*, 2017.

API 2218, *Fireproofing Practices in Petroleum and Petrochemical Processing Plants*, 2013.

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*, 2016.

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

ASME B31.1, *Power Piping*, 2018.

ASME B31.3, *Process Piping*, 2018.

2.3.3 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*, 2018.

ASTM D448, *Standard Classification for Sizes of Aggregate for Road and Bridge Construction*, 2017.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2019a.

ASTM E108, *Standard Test Methods for Fire Tests of Roof Coverings*, 2017.

ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, 2018ce1.

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 2019.

ASTM E814, *Standard Test Method for Fire Tests of Penetration Firestop Systems*, 2017.

ASTM E1248, *Standard Practice for Shredder Explosion Protection*, 2017.

ASTM E1725, *Standard Test Methods for Fire Tests of Fire-Resistive Barrier Systems for Electrical System Components*, 2014e1.

ASTM SI10, *American National Standard for Use of the International System of Units (SI): The Modern Metric System*, 2016.

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

IEC 62305, *Protection Against Lightning*, 2010.

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

IEEE C2, *National Electrical Safety Code*, 2017.

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 979, *Guide for Substation Fire Protection*, 2012.

IEEE 980, *Guide for Containment and Control of Oil Spills in Substations*, 2013.

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

2.3.6 SFPE Publications. Society of Fire Protection Engineers, 9711 Washingtonian Blvd, Suite 380, Gaithersburg, MD 20878.

Engineering Guide to Fire Risk Assessment, 2006.

SFPE Handbook of Fire Protection Engineering, edition.

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

UL 263, *Standard for Fire Tests of Building Construction and Materials*, 2011, revised 2018.

UL 723, *Test for Surface Burning Characteristics of Building Materials*, 2008, revised 2018.

UL 790, *Tests for Fire Resistance of Roof Covering Materials* 2004, revised 2014.

UL 900, *Standard for Safety Test Performance of Air Filters*, 2004, revised 2015.

UL 1479, *Standard for Fire Tests of Through-Penetration Firestops*, 2003, revised 2015.

UL 1709, *Standard for Rapid Rise Fire Tests of Protection Materials for Structural Steel*, 2017.

2.3.8 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

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*, 2018 edition.

NFPA 101®, *Life Safety Code*®, 2018 edition.

NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, 2020 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2018 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 oil-filled equipment such as transformers, current-limiting reactors, bushing cable boxes, or load tap changers a few milliseconds after the occurrence of an internal electrical arc.

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, 2018]

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, 2018]

3.3.11 Fire Prevention. Measures directed toward avoiding the inception of fire. [801, 2020]

3.3.12 Fire Protection. Methods of providing for fire control or fire extinguishment. [801, 2020]

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 Hybrid Fire-Extinguishing System. A fire-extinguishing system capable of delivering hybrid media at the specified design rate and proportion.

3.3.19 Hybrid Media. An extinguishing media created by the simultaneous discharge of water and an inert gas agent in a controlled proportion from a common discharge device that results in an oxygen concentration less than 18 percent.

3.3.20 Idling. A condition of the flywheel energy system where the flywheel is rotating but not providing energy to external loads.

3.3.21 Interior Finish. The exposed surfaces of walls, ceilings, and floors within buildings. [5000, 2018]

3.3.21.1 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 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.

3.3.21.2 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 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.

3.3.22 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 3500 Btu/lb (8141 kJ/kg), 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 0.127 in. (3.2 mm) 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 beyond the limits herein established through the effects of age, moisture, or other atmospheric condition are considered combustible.)

3.3.23 Liquid.

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

3.3.23.2 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).

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

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

3.3.24 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.

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

3.3.26 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.

3.3.27 Rating.

3.3.27.1 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.

3.3.27.2 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, 2018]

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

N 3.3.29* Spin Down. Shutdown condition of the flywheel energy system, where energy is being dissipated and the flywheel rotor is slowing down to a stop.

3.3.30 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 5.4.3).

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.)

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 Fire Risk Control Program

5.1 General.

5.1.1 This chapter provides recommended criteria for the development of a fire risk control program that contains administrative procedures and controls necessary for the execution of the fire prevention and fire protection activities and practices for electric generating plants and high voltage direct current converter stations.

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

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

5.2 Management Policy and Direction.

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

5.2.2 Proper preventive maintenance of operating equipment and adequate operator training are critical aspects of an effective fire prevention program. See Annex D for examples of operator errors causing significant property loss.

5.3 Fire Risk Control Program.

5.3.1 A written plant fire prevention program should be established and, at a minimum, should include the following:

- (1) Fire safety information for all employees and contractors. This information should include, at a minimum, familiarization with fire prevention procedures, plant emergency alarms and procedures, and how to report a fire. This should be included in employee/contractor orientation.
- (2) Documented, regularly scheduled plant inspections, including provisions for handling remedial actions to correct conditions that increase fire hazards.

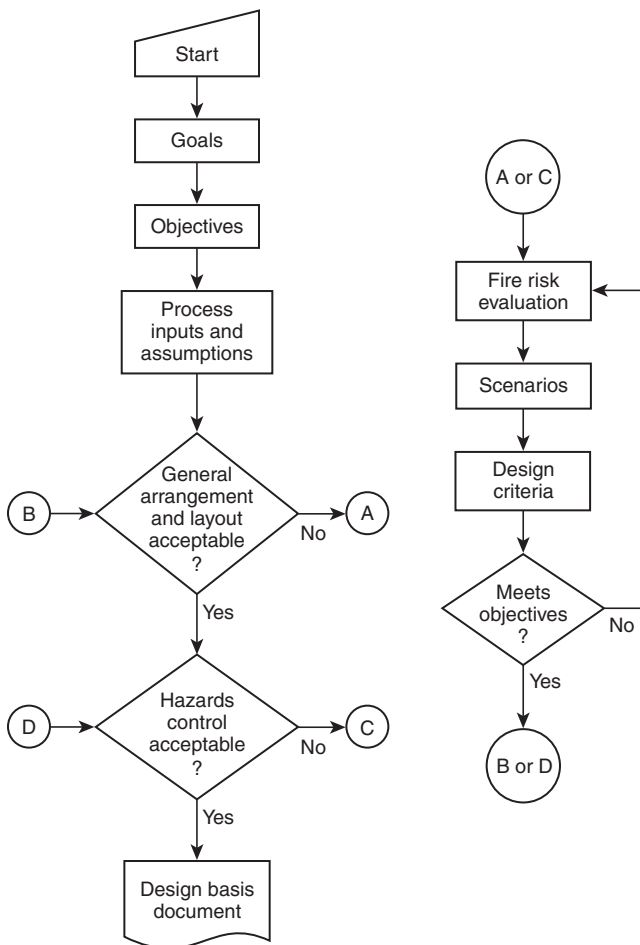


FIGURE 4.4.5 Fire Protection Design Basis Process Flow Chart.

- (3) A description of general housekeeping practices and the control of transient combustibles. Fire experience has shown that transient combustibles can be a significant factor during a fire situation, especially during outages.
- (4) Control of flammable and combustible liquids and gases in accordance with appropriate NFPA standards.
- (5) Combustible dust, as applicable, in accordance with NFPA 652.
- (6) Control of ignition sources including smoking, grinding, welding, and cutting. (See NFPA 51B.)
- (7) Fire prevention surveillance. (See NFPA 601.) Operational experience has demonstrated that roving operators and other plant personnel have been key factors in detection of fires and unsafe conditions. It is important that they be properly trained to observe and react to incipient fire situations. These should be reported to the control room operator for evaluation to determine what action is to be taken.
- (8) A fire report, including an investigation and a statement on the corrective action to be taken (see Annex B).
- (9) Fire hazards of materials located in the plant or storage areas identified in accordance with NFPA 704 and applicable material safety data sheets (MSDS).

N 5.3.2 A regular housekeeping program should be established to maintain combustible and other materials in designated storage areas.

5.4 Fire Protection Program.

5.4.1 Testing, Inspection, and Maintenance.

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

5.4.1.2* All fire protection systems and equipment should be periodically inspected, tested, and maintained in accordance with applicable *National Fire Codes*. (See Table 5.4.1.2 for guidance.)

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

5.4.2 Impairments.

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

- (1) Identify equipment not available for service
- (2) Identify personnel to be notified (e.g., plant fire brigade leader, public fire department, plant fire protection coordinator, control room operator)
- (3) Increase fire surveillance as needed [see 5.3.1(6)]
- (4) Provide additional protected measures as necessary (e.g., temporary water supplies, additional hose)

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

Table 5.4.1.2 Reference Guide for Fire Equipment Inspection, Testing, and Maintenance

Item	NFPA Document No.
Supervisory and fire alarm circuits	72
Fire detectors	72
Manual fire alarms	72
Sprinkler water flow alarms	25/72
Sprinkler and water spray systems	25/72
Foam systems	11/16/25
Halogenated agent, chemical and CO ₂ systems	12/12A/17/2001
Fire pumps and booster pumps	25/72
Water tanks and alarms	25/72
PIVs and OS & Y valves	25/72
Fire hydrants and associated valves	13/24
Fire hose and standpipes and hose nozzles	25/1962
Water additives	18A
Portable fire extinguishers	10
Fire brigade equipment	1971/1981/1982
Fire doors and dampers	80/90A
Smoke vents	204
Emergency lighting	110
Radio communication equipment	1221
Audible and visual signals	72
Water mist fire protection systems	750

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

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

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

- (1) Response to fire alarms and fire systems supervisory alarms
- (2) Notification of personnel identified in the plan
- (3) Evacuation of employees and visitors not directly involved in fire-fighting activities from the fire area
- (4) Coordination with security forces or other designated personnel to admit public fire department and control traffic and personnel

- (5) Fire preplanning that defines fire extinguishment activities and identification of fire water application concerns on operating equipment
- (6) Periodic drills to verify viability of the plan
- (7) Control room operator(s) and auxiliary operator(s) activities during fire emergencies
- (8) Procedures for grounding, isolating, or discharging of energy sources
- (9) Procedures for maintaining appropriate clearances to high-voltage electrical systems
- (10) Timely communication of all fire events to the responding fire brigade and the fire department

N 5.4.4.1 Emergency preplanning for the fire brigade and the fire department should include manual fire-fighting equipment utilization and deployment training.

N 5.4.4.2 Unattended Facilities.

N 5.4.4.2.1 Power generating plants that are operated unattended or with minimal staffing present special fire protection concerns.

N 5.4.4.2.2 Consideration should be given both to the delayed response time of the fire brigade or public fire-fighting personnel (which can be several hours) and to the lack of personnel available to alert others on site to a fire condition.

N 5.4.4.2.3 It is important that the responding fire brigade or public fire-fighting forces be familiar with access, plant fire protection systems, emergency lighting, specific hazards, and methods of fire control. This should be reflected in the plant fire emergency plan (*see 11.5.4*).

5.4.5 Emergency Response Personnel.

5.4.5.1 The size of the plant and its staff, the complexity of fire-fighting problems, and the availability of a public fire department should determine the requirements for emergency response personnel or fire brigade.

5.4.5.2 An emergency response team can be provided to facilitate response to emergencies such as fire. Activities can include incident command, incipient fire-fighting, escorting fire department personnel, first aid, HazMat First Responder duties, and so forth. The organization and responsibilities should be clearly identified.

5.4.5.3* If a fire brigade is provided, its organization and training should be identified in written procedures. NFPA 600 and OSHA standard 29 CFR 1910.156, "Fire Brigades," should be consulted for determining operation limitations.

5.4.6* Special Fire-Fighting Conditions. Electric generating plants present unique fire-fighting challenges. This information might be useful in fire preplanning. It could also be utilized in the education and training of both on-site and off-site fire-fighting personnel who would respond in the event of a fire emergency.

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

- (1) Tripping the turbine

- (2) Breaking condenser vacuum
- (3) Emergency purging of the generator
- (4) Shut down main and backup oil pumps

Shutting down oil pumps can cause additional mechanical damage to the turbine depending on rotating speed. However, it can be effective in mitigating the overall damage due to fire. (*See Annex D.*) When ac oil pumps are shut down, dc or backup pumps will start on low pressure. The dc or backup oil pumps will also have to be secured, which usually requires more than operating a switch.

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

N 5.4.6.3 Scrubbers.

N 5.4.6.3.1 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) A fire protection system should be provided in the duct systems during maintenance operations. A fixed protection duct system on the scaffolding is recommended. The duct system should be designed to protect the work platform and twice the area that can be reached by workers on the platform.
- (3) Due to the unique design and operating features of scrubbers, fire protection designers should consult with the scrubber manufacturer for guidance as to material selection for internal fire protection systems and specific protection design features.
- (4) Standpipes should be provided such that 1½ in. (3.8 cm) hose is available at scrubber access hatches that are open during outages.
- (5) The introduction of combustible materials into the scrubber should be limited and controlled during maintenance and inspection outages.

N 5.4.6.3.2 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.

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

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

5.4.6.6 Hydrogen System. Hydrogen has a relatively large flammability range (4 to 75 percent by volume) in air. The explosive range (for deflagrations and detonations) is narrower than the flammability range, but hydrogen explosions can occur inside turbine halls in the event of accidental release and delayed ignition. Under most conditions, it is safer to allow a hydrogen fire to burn in a controlled manner until such time as the gas source can be shut off. Extinguishing the fire while gas is still escaping could allow an explosive mixture to be generated. The Fire Protection Design Basis Document should include provisions so that hydrogen supplies can be shut off from a readily accessible location outside the fire area if called for in an emergency situation.

5.4.6.7* **Fuel Storage and Handling.**

5.4.6.7.1 Once the location and extent of a fire in a solid-fuel storage pile have been determined, the fuel should be dug out and the heated fuel removed. Because moisture accelerates oxidation, water used for fire-fighting can aggravate the situation if the seat of the fire is not reached. Water additives should be considered, to break the water tension and improve penetration.

▲ **5.4.6.7.2** Clearly marked access panels in equipment should be provided for manual fire-fighting. Combustible dust presents both a fire and explosion hazard. Combustible, finely divided material is easily ignited. However, there is a possibility that a deep-seated hard-to-extinguish fire can occur. Application of an extinguishing agent that disturbs dust deposits could result in a dust explosion.

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

5.4.6.8 Coal Pulverizers. (See 9.5.4 of NFPA 85.) Additional information can be obtained from published manufacturer's instructions.

5.5 Identification of Fire Hazards of Materials. Materials located in the plant or storage areas should be identified in accordance with NFPA 704 and the applicable SDS.

Chapter 6 General Plant Design

6.1 Plant Arrangement.

6.1.1 Fire Area Determination.

6.1.1.1 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.

6.1.1.2 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

▲ **6.1.1.3*** Unless consideration of the factors of 6.1.1.2 indicates otherwise or if adequate spatial separation is provided as permitted in 6.1.1.5, 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, combustion turbines, and other internal combustion engines 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 fuel 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 6.4*)]
- (18) Switchgear area and sulfur hexafluoride (SF₆) switchyard area from adjacent areas

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

6.1.1.5 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.

6.1.1.6 Particular care should be practiced with respect to adequate spatial separation and protection from wildland fires as well as the control of vegetation. Guidance regarding vegetation clearance, separation distance, and emergency planning can be found in NFPA 1143 and NFPA 1144.

6.1.2 Openings in Fire Barriers.

6.1.2.1* 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, *Standard for Cable-Penetration Fire Stop Qualification Test*, or UL 1479, *Standard for Fire Tests of Through-Penetration Firestops*, are permitted to be considered for this application.

6.1.2.2 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.*)

6.1.3 Hydrogen Storage. Hydrogen storage facilities should be separated from adjacent areas. (*See NFPA 2.*)

6.1.4 Outdoor Oil-Insulated Transformers.

6.1.4.1 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.

6.1.4.2 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.

6.1.4.3* Unless consideration of the factors in 6.1.4.2 indicates otherwise, it is recommended that any oil-insulated transformer, including the edge of the postulated oil spill, be separated from adjacent structures by a 2-hour-rated firewall or by spatial separation in accordance with Table 6.1.4.3. Where a firewall is provided between structures and a transformer, it should extend vertically and horizontally as indicated in Figure 6.1.4.3.

6.1.4.4 Unless consideration of the factors in 6.1.4.2 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 6.1.4.3. When the oil containment, as shown in Figure 6.1.4.4, 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 6.5.6 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 6.1.4.4 for an illustration of the recommended dimensions for a firewall.*)

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

6.1.4.6 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 6.1.4.2 and 6.1.4.5.

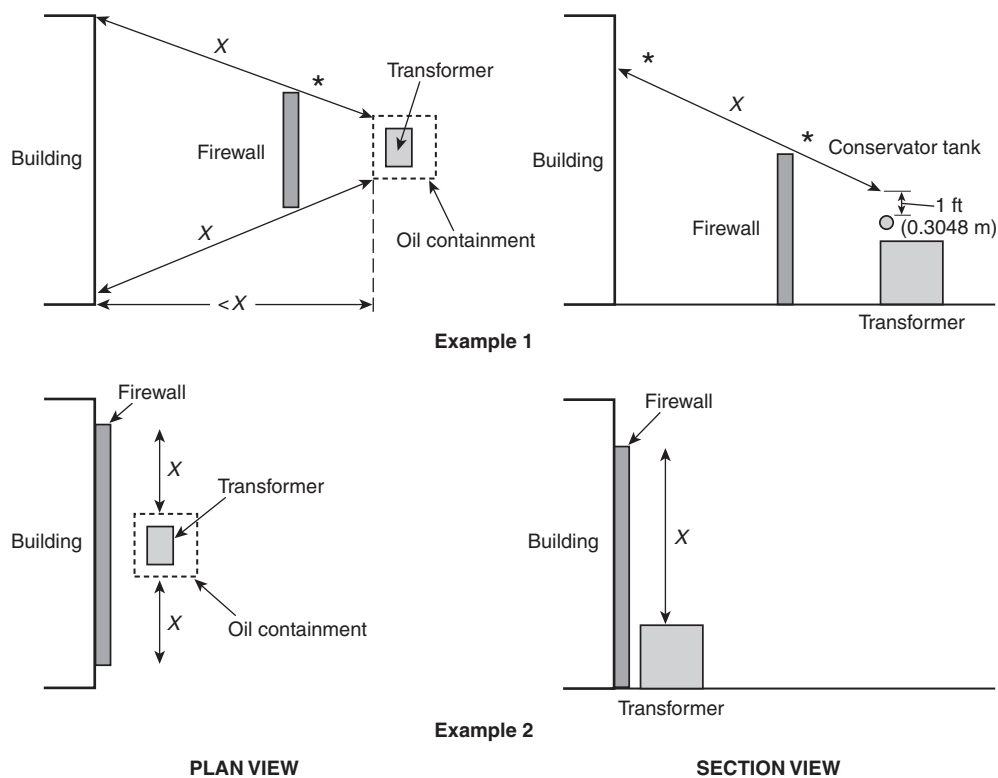
6.1.5 Indoor Transformers and Other Oil-Filled Electrical Equipment.

6.1.5.1 Dry-type transformers and other non-oil-filled electrical equipment are preferred for indoor installations. Dry-type capacitors or capacitors filled with a less flammable liquid should be considered to minimize the fire risk associated with oil-filled equipment.

6.1.5.2* Oil-insulated transformers or other oil-filled electrical equipment 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.

Table 6.1.4.3 Outdoor Oil-Insulated Transformer Separation Criteria

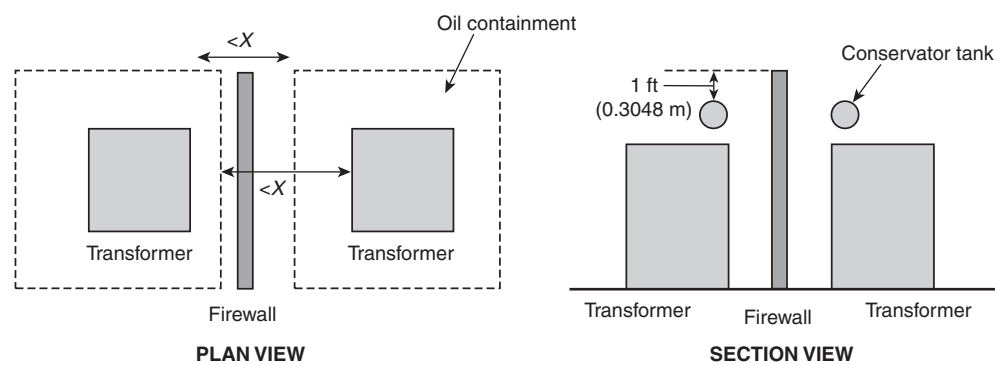
Transformer Oil Capacity		Minimum (Line-of-Sight) Separation Without Firewall	
gal	L	ft	m
<500	<1893	5	1.5
500–5000	1893–18,925	25	7.6
>5000	>18,925	50	15



X: Minimum separation distance from Table 6.1.4.3.

*: See A.6.1.4.3.

FIGURE 6.1.4.3 Illustration of Oil-Insulated Transformer Separation Recommendations.



X: Minimum separation distance from Table 6.1.4.3.

FIGURE 6.1.4.4 Outdoor Oil-Insulated Transformer Separation Criteria.

6.1.5.3 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.

6.1.5.4 Where transformers or other oil-filled electrical equipment are protected by an automatic fire suppression system, the fire barrier fire resistance rating should be permitted to be reduced to 1 hour.

6.1.5.5 Automatic sprinkler, foam-water spray, water spray, and compressed air foam systems should be considered for oil-filled electrical equipment. Where the hazard is not great enough, according to the hazard analysis, to warrant a fixed fire suppression system, automatic fire detection should be considered (see 7.7.2).

6.1.6* General Substation Arrangement. The following documents should be considered for arrangement and protection of substations and switchyards:

- (1) IEEE 979, *Guide for Substation Fire Protection*
- (2) IEEE 980, *Guide for Containment and Control of Oil Spills in Substations*

6.2 Life Safety.

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

6.2.2* 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) Fuel 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.

6.2.3 In the event of a plant fire, egress of occupants in control facilities can be delayed due to emergency shutdown procedures. (See 40.2.5.1.2 of NFPA 101.) Control facilities should have a means of egress that is separated from other plant areas to facilitate a delayed egress.

6.2.4 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.

6.3 Building Construction Materials.

6.3.1 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
- (2) ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, or UL 263, *Standard Test Methods for Fire Tests of Building Construction and Materials*
- (3) NFPA 253
- (4) NFPA 259
- (5) ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or UL 723, *Test for Surface Burning Characteristics of Building Materials*

6.3.2 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 6.3.4
- (2) Limited use of translucent reinforced plastic panels as allowed by the Fire Protection Design Basis Document

6.3.3 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.

6.3.4 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.”

6.3.5 Interior Finish.

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

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

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

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

6.4.1* Smoke and Heat Venting.

6.4.1.1 General.

6.4.1.1.1 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.

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

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

6.4.1.1.4* Ventilation exhaust systems, particularly those for subsurface portions of underground facilities, should have fans able to operate continually to exhaust smoke and chemical fumes that can result from fires or from extinguishing of fires. The design and selection of the fans and other elements of the system should take into account additional ventilation needs for removing smoke and high-temperature gases. Therefore, the fan and its associated components, along with any ductwork, should be capable of handling high temperatures without deforming. Total fan capacity should be provided so that ventilation requirements can be met with the largest fan out of

service. The specific weight and volume of the heated air during a fire and the climatic conditions should also be considered.

6.4.1.2 Heat Vents.

6.4.1.2.1 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.

6.4.1.2.2 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.)

6.4.1.3 Smoke Vents.

6.4.1.3.1 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.

6.4.1.3.2* 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.

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

6.4.1.3.4 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.

6.4.1.3.5 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.

6.4.1.3.6 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.

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

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

6.4.2.2 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.

6.4.2.3 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.

6.4.2.4 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 6.1).

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

6.4.2.6 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 shutdown or closure on detection of smoke. Separation from exhaust air outlets, smoke vents from other areas, and outdoor fire hazards should all be considered. For unattended or hydro-electric generating stations, manual override should be located at the entry to the plant so that emergency responders can activate these controls upon arrival.

N 6.4.2.7 Fire hazards should not be located in the principal access or air supply (e.g., conduits, shafts, tunnels) in order to avoid loss of fresh air in the event of a fire.

6.5 Containment and Drainage.

6.5.1* 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
- (7) Porous ground surfaces such as stone or soil

Δ 6.5.1.1* 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

N 6.5.1.2 Independent of the above, the drainage systems should consider the maximum water introduced by the wash-down systems. 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.

N 6.5.1.3 A means to direct leaking flammable fluid away from important equipment and structures should be provided. Sloping the ground to channel leaking fluid to safe areas and curbs to prevent flow toward equipment are some methods that can be used.

N 6.5.1.4 An emergency power supply should be provided for principal drainage pumps in areas where flooding would be dangerous.

6.5.2 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 any 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.

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

6.5.4 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.

6.5.5 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 6.5.1.1. 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.

6.5.5.1 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.

6.5.5.2 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 D448, *Standard Classification for Sizes of Aggregate for Road and Bridge Construction*).

6.5.6 For facilities consisting of more than one generating unit that are not separated by a fire barrier [see 6.1.1.3(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.

6.5.7 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).

6.6 Emergency Lighting.

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

6.6.2 Emergency lighting should be provided for critical plant operations areas. A normally unattended site emergency lighting system for critical operating areas that depends on batteries or fuel supplies should be manually operated from a switch at the entry to the plant. The emergency lighting can be permitted to consist either of fixed units or of portable lights.

6.7 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 7 General Fire Protection Systems and Equipment

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

7.2 Water Supply.

7.2.1* 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 6.1.4]
- (2) The hose stream demand of not less than 500 gpm (1893 L/min)
- (3) Incidental water usage for non-fire protection purposes

7.2.2* 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

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

7.2.3 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.

7.2.3.1 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 7.2.2.

7.2.4 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.

7.2.5 Fire Pumps.

7.2.5.1 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 7.2.1 with the largest pump out of service.

7.2.5.2 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.

7.2.6 Water Supply Tanks.

7.2.6.1 If tanks are of dual-purpose use, a standpipe or similar arrangement should be provided to dedicate the amount determined by 7.2.1 for fire protection use only. (See NFPA 22.)

7.2.6.2 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.

7.3 Valve Supervision. All fire protection water supply and system control valves should be under a periodic inspection program (see Chapter 5) 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.

7.4 Supply Mains, Yard Mains, Hydrants, and Building Standpipes.

7.4.1 Supply Mains, Yard Mains, and Hydrants.

7.4.1.1 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 solid-fuel storage should be a maximum of 500 ft (152.4 m).

7.4.1.2 Consideration should be given to the placement of hydrants and monitors about the area to provide strategic coverage of all flammable or combustible liquids piping. Based on the completed Fire Protection Design Basis Document, an alternative could be the use of fire/water trucks if the site water supply so dictates.

7.4.1.3 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.

7.4.1.4 The supply mains should be looped around the main power block and should be of sufficient size to supply the flow requirements determined by 7.2.1 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.

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

7.4.1.6 Each hydrant should be equipped with a separate shut-off valve located on the branch connection to the supply main.

7.4.1.7 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.

7.4.1.8 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.

7.4.2 Standpipe and Hose Systems.

7.4.2.1 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.

7.4.2.2 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.)

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

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

7.4.3 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.

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

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

7.6 Fire Suppression Systems and Equipment — General Requirements.

Δ 7.6.1 Fire suppression systems and equipment should be provided in all areas of the plant as identified in subsequent chapters or as determined by the Fire Protection Design Basis Document. Fixed suppression systems should be listed and sized for the application and designed, installed, and commissioned in accordance with the manufacturer's recommendations and the following codes and standards unless specifically noted otherwise:

- (1) NFPA 11
- (2) NFPA 12
- (3) NFPA 13
- (4) NFPA 15
- (5) NFPA 16
- (6) NFPA 17
- (7) NFPA 18A
- (8) NFPA 20
- (9) NFPA 24
- (10) NFPA 25
- (11) NFPA 214
- (12) NFPA 750
- (13) NFPA 2001
- (14) NFPA 2010

N 7.6.2* Fire suppression and fire-extinguishing systems should be sized to be capable of providing protection for as long as the hazards of hot metal surfaces above the autoignition temperature (AIT) and uncontrolled combustible liquid flow exist (consult manufacturer for cooldown times or obtain machine-specific data).

Δ 7.6.3 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 and ability to remove the agent, the toxic gases, and the combustion products from these structures following system actuation
- (4) Need for and ability to minimize agent leakage by sealing of electrical enclosures as well as room integrity and automatic closing of ventilation dampers and doors, as applicable, and automatic shutdown of fans
- (5) Extinguishing agent discharge should be based on concentration while hazard is above the autoignition temperature
- (6)* Potential for causing flooding or environmental damage

N 7.6.4 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.

N 7.6.5 Automatic Sprinkler and Water Spray Systems.

N 7.6.5.1 Automatic sprinkler and water spray systems, including systems with water additives, where provided, should follow the recommendations in Chapter 9 and the following criteria:

- (1) If permitted by the turbine configuration, water spray nozzles provided to protect the combustion turbine power bearing housings behind the exhaust duct should be directed based on unit geometry to avoid possible water damage.
- (2)* Depending on unit packaging arrangement, consideration should be given to closing the fuel valves automatically on water flow. This action should not be taken for ICE emergency power supply systems (e.g., hospital emergency power).
- (3) Turbochargers on ICEs constitute a part of the hazard, and protection should be provided.

N 7.6.6* Total Flooding Gaseous Systems. Where total flooding gaseous agent systems are used, the system should be listed and installed in accordance with NFPA 12, NFPA 12A, or NFPA 2001, and the manufacturer's installation procedures.

N 7.6.6.1 Where total flooding gaseous systems are used, the engine enclosure should be arranged for minimum leakage by automatic shutdown of fans and automatic closing of doors, ventilation dampers, and other openings. CT or ICE compartments are designed to be capable of nominally airtight closure. During operation there is, however, a need for substantial amounts of secondary cooling (compartment ventilation) air. This air can be moved through the compartments by fans or venturi action from the CT or ICE air. This air flow will not stop immediately upon shutdown, and, therefore, it should be considered in the extinguishing system design.

N 7.6.6.2 Maintenance of total flooding systems is particularly critical. The integrity of the enclosure to be flooded and the interlocks between the fire system and associated equipment, such as the ventilation system dampers, should be maintained. The enclosure's integrity should be verified whenever it has been disassembled or modified. This can be done by a door fan test or other quantified means of detecting leakage. The leakage test should be conducted at least every 5 years. Maintenance and testing of the fire protection system should be conducted as defined in the applicable suppression standard.

N 7.6.6.3 It should be noted that deep-seated fires, such as oil-soaked insulation, can be present and will require manual extinguishment after the gaseous system soak time.

N 7.6.6.4 Provisions should be made to safely remove the gas and potential toxic combustion by-products from the enclosure following gaseous system actuation.

N 7.6.7 Total Flooding Water Mist Systems.

N 7.6.7.1 Where total flooding water mist systems are used, the system should be installed in accordance with NFPA 750 and should be listed for the application. The system should be installed in accordance with the manufacturer's installation procedures.

N 7.6.7.2 The enclosure should be arranged for minimum leakage by automatic shutdown of fans and automatic closing of the doors, ventilation dampers, and other openings. Where equipment is operating, there is a need for substantial amounts of secondary cooling (e.g., compartment ventilation) air. This air flow will not stop immediately upon shutdown, and, therefore, it should be considered in the extinguishing system design.

N 7.6.8 Hybrid Fire-Extinguishing Systems.

N 7.6.8.1 Where hybrid fire-extinguishing systems are used, the system should be installed in accordance with the listed configuration and the manufacturer's design and installation procedures.

N 7.6.8.2 The enclosure should be arranged for minimum leakage by automatic shutdown of fans and automatic closing of doors, ventilation dampers, and other openings. Where equipment is operating, there is a need for substantial amounts of secondary cooling (e.g., compartment ventilation) air. This airflow will not stop immediately upon shutdown, and therefore, it should be considered in the extinguishing system design.

N 7.6.9 Localized Extinguishing Systems.

N 7.6.9.1 Where units are not enclosed and a first level of protection is desired that will operate before sprinklers, or where sprinklers are not installed, a localized extinguishing system might be appropriate. Such a system should be of a listed local application type such as water mist, compressed air foam, carbon dioxide, or dry chemical.

N 7.6.9.2 Discharge rates and duration of discharge should be such that cooling and shutdown occur to prevent reignition of the fire. System operation should be arranged to close fuel valves.

N 7.6.9.3 The positioning of local application nozzles should be such that maintenance access to the turbine or engine is not obstructed.

N 7.6.10 High-Expansion Foam Systems. Where provided, high-expansion foam systems should be installed in accordance with the requirements of NFPA 11.

N 7.6.11 Compressed Air Foam Systems. Where provided, compressed air foam systems should be installed in accordance with the requirements of NFPA 11.

N 7.6.12 Fixed Aerosol Fire-Extinguishing Systems. Where provided, fixed aerosol fire extinguishing systems should be installed in accordance with the requirements of NFPA 1010.

7.6.13 Fire Suppression System Safety Considerations.

7.6.13.1 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.

7.6.13.2 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.

7.6.13.3 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.

7.6.13.4 NFPA standards for the extinguishing systems used should be carefully studied and the personnel safety provisions followed. (See NFPA 12.)

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

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

7.6.13.4.3 Personnel warning signs should be used as necessary.

7.6.13.4.4 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).

7.7 Fire-Signaling Systems.

7.7.1 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.)

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

7.7.3 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 or in other special cases (e.g., confined spaces, scroll/spiral cases, draft tubes) to alert personnel that a fire alarm system has been activated 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. Remote annunciation of the fire-signaling panel to one or more constantly attended locations is critical for emergency response.
- (5) At unattended plants, the fire-signaling panel should be located at the entry.

N 7.7.4 Annunciation of fire-signaling systems to a constantly attended location is critical for emergency response. The location and design of fire-signaling systems, including emergency shutdown stations and their interfaces with facility control and information systems, should be considered.

N 7.7.5 Vapor or Gas Detection.

N 7.7.5.1 Vapor detection should be provided to allow early warning for equipment subject to leaks of flammable fluid or vapors so corrective action can be taken.

N 7.7.5.1.1 Vapor detection systems should alarm at a constantly attended location, such as the control room. The following should be considered:

- (1) Alarm from one detector should be investigated immediately.
- (2) Consideration should be given to automatic equipment shutdown in the event two detectors alarm simultaneously.

N 7.7.5.1.2 For unattended plants, vapor detection should provide for automatic shutdown and notification.

N 7.8 Commissioning and Maintenance.

N 7.8.1 Fire protection systems should be functionally tested to verify operation, integrity, and flow of the nozzles at the completion of commissioning activities and any time maintenance requires disassembly of the fire protection system.

N 7.8.2 Maintenance and testing of the fire protection system should be conducted as defined in the applicable standard.

Chapter 8 Fire Protection for the Construction Site**8.1 Introduction.**

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

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

8.1.3 For fire protection for plants and areas under construction, see NFPA 241. Chapter 8 addresses concerns not specifically considered in NFPA 241.

8.2 Administration.

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

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

8.2.3 The fire prevention and fire protection program should include a Fire Protection Design Basis Document of the construction site and construction activities at any construction site. (See Chapter 4.)

8.2.4 Written procedures should be established for the new construction site, including major construction projects in existing plants. Such procedures should be in accordance with Sections 5.3 and 5.4, and 5.4.2, 5.4.4, and 5.4.5.

8.2.5 Security guard service, including recorded rounds, should be provided through all areas of construction during times when construction activity is not in progress. (See NFPA 601.)

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

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

8.2.5.3 In areas where automatic fire detection or extinguishing systems are in service, with alarm annunciation at a constantly attended location, or in areas of limited combustible loading, rounds are permitted to be omitted after the first round indicated in 8.2.5.1.

8.2.6 Construction schedules should be coordinated so that planned permanent fire protection systems are installed and placed in service as soon as possible, at least prior to the introduction of any major fire hazards identified in Chapter 9.

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

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

8.3 Site Clearing, Excavation, Tunneling, and Construction Equipment.**8.3.1 Site Clearing.**

8.3.1.1 Prior to clearing forest and brush-covered areas, the owner should ensure that a written fire control plan is prepared and that fire-fighting tools and equipment are made available as recommended by NFPA 1143. Contact should be made with local fire and forest agencies for current data on restrictions and fire potential, and to arrange for necessary permits.

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

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

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

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

8.3.1.6 Where it is necessary to dispose of combustible waste by on-site burning, designated burning areas should be established with approval by the owner and should be in compliance with federal, state, and local regulations and guidelines. The contractor should coordinate burning with the agencies responsible for monitoring fire danger in the area and should obtain all appropriate permits prior to the start of work. (See Section 8.2.)

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

8.3.2 Excavation and Tunneling.

8.3.2.1 Construction activities related to tunnels, shafts, and other underground excavations are strictly regulated by federal and state agencies. Fire prevention consists of adequate ventilation, good housekeeping, and limiting the types of fuel, explosives, and combustibles underground as well as adjacent to entrances and ventilation intakes. Inspections of site conditions and the testing of air quality should be assigned to qualified personnel specifically trained in the use of those instruments specified by the regulating agency.

8.3.2.2 Pre-excavation geologic surveys should include tests for carbonaceous or oil-bearing strata, peat, and other organic deposits that can be a source of combustible dusts or explosive gases.

8.3.2.3 The use of vehicles and equipment requiring gasoline, liquefied petroleum gas, and other fuels in excavations with limited air circulation should be restricted.

8.3.2.4 A general plan of action for use in times of emergency should be prepared for every underground excavation. (See Section 1.2.)

8.3.2.5 Construction Equipment. Construction equipment should meet the requirements of NFPA 120.

8.4 Construction Warehouses, Shops, and Offices.

8.4.1 All structures that are to be retained as part of the completed plant should be constructed of materials as indicated in Chapter 6 and should be in accordance with other recommendations for the completed plant.

8.4.2 Construction warehouses, offices, trailers, sheds, and other facilities for the storage of tools and materials should be located with consideration of their exposure to major plant buildings or other important structures. For guidance in separation and protection, see NFPA 80A and NFPA 1144.

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

8.4.4 Warehouses that contain high value equipment (as defined by the individual responsible for fire prevention and fire protection), or where the loss of or damage to contents would cause a delay in startup dates of the completed plant, should be arranged and protected as indicated in 8.4.4 through 8.4.10. Although some of these structures are considered to be “temporary” and will be removed upon completion of the plant, the fire and loss potential should be thoroughly evaluated and protection provided where warranted.

8.4.4.1 Building construction materials should be noncombustible or limited combustible. (See Chapter 6.)

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

8.4.4.3 Air-supported structures sometimes are used to provide temporary warehousing space. Although the fabric envelope can be a fire-retardant material, the combustibility of contents and the values should be considered, as with any other type of warehouse. Because it is impractical to provide automatic sprinkler protection for them, air-supported structures should be used only for noncombustible storage. An additional factor to consider is that relatively minor fire damage to the fabric envelope can leave the contents exposed to the elements.

8.4.5 Temporary enclosures, including trailers, inside permanent plant buildings should be prohibited except where permitted by the individual responsible for fire prevention and fire protection. Where the floor area of a combustible enclosure exceeds 100 ft² (9.3 m²) or where the occupancy presents a fire exposure, the enclosure should be protected with an approved automatic fire extinguishing system.

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

- (1) An approved automatic fire extinguishing system is in service in the storage area
- (2) Where loss of the materials or loss to the surrounding plant area would be minimal, as determined by the individual responsible for fire prevention and fire protection

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

8.4.7.1 Mobile buildings should be installed and located according to the requirements of NFPA 501A. Insulating materials utilized in mobile buildings should be noncombustible.

8.4.7.2 Construction camp buildings should be designed and installed in accordance with NFPA 101.

8.4.8 Fire alarms should be connected to a constantly attended central location. All premise fire alarm systems should be installed, tested, and maintained as outlined in NFPA 72. An alternative to remote alarms would be audible and visual alarms that would alert site/security personnel to abnormal conditions.