NFPA®

804

Standard for Fire Protection for Advanced Light Water Reactor Electric Generating Plants

2020

NFPA® 804

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Fire Protection for Advanced Light Water Reactor Electric Generating Plants

2020 Edition

This edition of NFPA 804, *Standard for Fire Protection for Advanced Light Water Reactor Electric Generating Plants*, was prepared by the Technical Committee on Fire Protection for Nuclear Facilities. 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 edition of NFPA 804 was approved as an American National Standard on November 24, 2019.

Origin and Development of NFPA 804

The need for fire protection in nuclear power facilities has been demonstrated in a number of incidents, including the Browns Ferry Fire in 1975 and other more recent incidents in the United States and abroad. Probabilistic risk assessments of existing plants have shown that fire represents one of the largest single contributors to the possibility of reactor damage. This document, first released in 1995, represents a comprehensive consensus of baseline fire protection requirements for all aspects of advanced light water reactor electric generating plants, including their design, construction, operation, and maintenance.

There were no technical changes made in the 2001 edition. All the changes were in the definitions section to comply with the NFPA Glossary of Terms.

The 2006 edition was reorganized to conform to the *Manual of Style for NFPA Technical Committee Documents*.

For the 2010 edition, the document scope was revised in order to coordinate with the release of and option to use a new risk-informed option for atomic power plants under NFPA 806, *Performance-Based Standard for Fire Protection for Advanced Nuclear Reactor Electric Generating Plants Change Process*. The 2010 edition was also harmonized with other documents in the field, and a new Annex B was added for best practice guidance for defense against fires and explosions.

The 2015 edition of the document was updated to remove references to NFPA 251, which was withdrawn. Changes also were made to include the definition and requirements from NFPA *101* and NFPA 1144 pertaining to combustible, noncombustible, and limited combustible materials.

Several changes have been made to the 2020 edition to comply with the *Manual of Style for NFPA Technical Committee Documents* and align terms with NFPA 801, 805, and 806. To ensure proper operation of all plant systems, a recommendation to use NFPA 4 to test integrated fire protection systems has been added in Annex A, Chapter 5. To ensure the proper selection of an extinguishing agent, additional consideration criteria that align with NFPA 801 have been included. Additional language from NFPA *101* has also been incorporated to more clearly identify materials that should be considered limited-combustible.

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

Committee Scope: This Committee shall have primary responsibility for documents on the safeguarding of life and property from fires in which radiation or other effects of nuclear energy might be a factor.

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Standard for

Fire Protection for Advanced Light Water Reactor Electric Generating Plants

2020 Edition

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

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1* Scope. This standard applies only to advanced light water reactor electric generating plants and provides minimum fire protection requirements to ensure safe shutdown of the reactor, minimize the release of radioactive materials to the environment, provide safety to life of on-site personnel, limit property damage, and protect continuity of plant operation. The fire protection is based on the principle of defense-in-depth. For plants that have adopted a risk-informed, performance-based approach to fire protection, subsequent changes to the fire protection program shall be made in accordance with NFPA 806.

1.2 Purpose.

1.2.1 This standard is prepared for use by and guidance of those charged with the design, construction, operation, and regulation of advanced light water reactor electric generating plants.

1.2.2 This standard covers those requirements essential to ensure that the consequences of fire will have minimum impact on the safety of the public and on-site personnel, the physical integrity of plant components, and the continuity of plant operations.

1.3 Equivalency. Nothing in this standard 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 standard.

1.3.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.3.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.4 Units and Formulas. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The liter unit, which is commonly used in international fire protection, is not part of but is recognized by SI. Conversion factors for these units are found in Table 1.4.

Table 1.4 Metric Units of Measure

Name of Unit	Unit Symbol	Conversion Factor
Bar	bar	1 psi = 0.0689 bar
Bar	bar	1 bar = 10^5 Pa
Cubic decimeter	dm^3	1 gal = 3.785 dm^3
Kilogram	kg	1 lb = 0.4536 kg
Kilopascal	kPa	1 psi = 6.895 kPa
Liter	L	1 gal = 3.785 L
Liter per minute per square meter	$L/min \cdot m^2$	1 gpm/ft^2 = 40.746 $L/min \cdot m^2$
Meter	m	1 ft = 0.3048 m
Millimeter	mm	1 in. =25.4 mm
Millimeters of mercury	mm Hg	1 psi = 51.72 mm Hg
Pascal	Pa	1 psi = 6894.757 Pa

Note: For additional conversions and information, see IEEE/ASTM SI 10, *American National Standard for Metric Practice.*

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

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

NFPA 10, *Standard for Portable Fire Extinguishers*, 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 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 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 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 58, *Liquefied Petroleum Gas Code*, 2020 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 80, *Standard for Fire Doors and Other Opening Protectives*, 2019 edition.

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

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

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

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel–Burning Appliances*, 2019 edition.

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

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

NFPA 232, *Standard for the Protection of Records*, 2017 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 259, *Standard Test Method for Potential Heat of Building Materials*, 2018 edition.

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

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

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*, 2019 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 806, *Performance-Based Standard for Fire Protection for Advanced Nuclear Reactor Electric Generating Plants Change Process*, 2020 edition.

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

NFPA 1500™, *Standard on Fire Department Occupational Safety, Health, and Wellness Program*, 2020 edition.

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

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

2.3 Other Publications.

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

ASME Boiler and Pressure Vessel Code, Section III, 2017.

ASME B31.1, *Power Piping*, 2016.

ASME NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities*, 2017.

2.3.2 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*, 2016.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2018.

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

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 2016.

ASTM E814, *Standard Method for Fire Tests of Penetration Firestop Systems*, 2013a (2017).

ASTM E2652, *Standard Test Method for Behavior of Materials in a Tube Furnace with a Cone-Shaped Airflow Stabilizer, at 750°C*, 2016.

ASTM E2965, *Standard Test Method for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter*, 2016.

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

ANSI/IEEE C2, *National Electrical Safety Code®*, 2017.

IEEE 383, *Standard for Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations*, 1974 (rev. 2015).

IEEE 1202, *Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies*, 2006.

IEEE/ASTM SI 10, *American National Standard for Metric Practice*, 2017.

2.3.4 NEI Publications. Nuclear Energy Institute, 1201 F Street, NW, Suite 1100, Washington, DC 20004-1218.

NEI 00-01, *Guidance for Post-Fire Safe Shutdown Circuit Analysis*, prepared by NEI Circuit Failure Issues Task Force, October 2011.

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

UL 586, *Standard for Test Performance of High-Efficiency Particulate Air Filter Units*, 2009, revised 2014.

UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, 2008, revised 2013.

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

UL 2196, *Standard for Tests of Fire Resistive Cables*, 2017.

2.3.6 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

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

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

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

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

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be 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 Shall. Indicates a mandatory requirement.

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

3.2.7 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1* Advanced Light Water Reactors (ALWRs). ALWRs are next generation light water reactors.

3.3.2 Alternative Shutdown Capability. The ability to safely shut down the reactor and maintain shutdown using equipment and processes outside the normal reactor shutdown process.

3.3.3* Associated Circuits of Concern. Safety-related and non-safety-related circuits that are not directly required to perform a safe shutdown function and that do not have a required physical separation.

3.3.4 Cable Tray Fire Break. A noncombustible or limited-combustible material installed in vertical or horizontal cable trays to limit fire spread.

3.3.5 Cold Shutdown. A stable nuclear power plant condition in which the affected reactor is subcritical and the average reactor coolant system temperature is less than or equal to 200°F (93°C).

3.3.6 Combustible. A combustible material is any material that, in the form in which it is used and under the conditions anticipated, will ignite and burn or will add appreciable heat to an ambient fire. [**1144,** 2018]

3.3.7 Combustible Liquid. A liquid that has a closed-cup flash point at or above 100°F (37.8°C).

3.3.8* Defense-in-Depth. A principle aimed at providing a high degree of fire protection by achieving a balance of preventing fires from starting; detecting fires quickly and suppressing those fires that occur, thereby limiting damage; and designing a nuclear power plant to limit the loss of life, property, and environment to fire and to ensure continuity of nuclear power plant operation and safe shutdown capability.

3.3.9* 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. [**805,** 2020]

3.3.10* Fire Area Subdivision. A portion of a fire area that is separated from the remainder of the fire area by substantive barriers, which are not necessarily fire rated; by physical features, such as pipe tunnels; by spatial separation.

3.3.11 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. (SAF-FIR) [*101*, 2018]

3.3.12 Fire Door. A door assembly rated in accordance with NFPA 252 and installed in accordance with NFPA 80.

3.3.13 Fire Hazards Analysis (FHA). An analysis to evaluate potential fire hazards and appropriate fire protection systems and features to mitigate the effects of fire in any plant location.

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

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

3.3.16 Fire Protection Manager. The person directly responsible for the fire prevention and fire protection program at the plant.

3.3.17* Fire Resistance Rating. The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with an approved test procedure appropriate for the structure, building material, or component under consideration. [**805**, 2020]

3.3.18 Fire-Rated Cables. Cables with an hourly fire resistance rating based on maintaining functionality when tested in accordance with UL 2196, *Standard for Tests of Fire Resistive Cables*.

3.3.19 Fire-Rated Internal Conduit Seal. A conduit seal that is a tested and approved hourly rated fire seal in accordance with ASTM E814, *Standard Method for Fire Tests of Penetration Firestop Systems*.

3.3.20 Fire-Rated Penetration Seal. An assembly provided in a fire barrier opening for the passage of pipes, cable trays, and so forth, to maintain the fire resistance rating of the fire barrier.

3.3.21 Fire-Safe Shutdown (FSSD). Actions, components, capabilities, and design features necessary to achieve and maintain safe shutdown of the reactor after a fire in a specific fire area.

3.3.22* Fire-Safe Shutdown Component. Component (nuclear safety related and non–safety related), equipment, instrument-sensing line, or cable, including associated circuits of concern, that is required to safely shut down a nuclear plant in the event of fire.

3.3.23* First Break. The first place in a conduit run where the interior of the conduit is accessible to install a seal.

3.3.24 Flame Spread Index. A comparative measure, expressed as a dimensionless number, derived from visual measurements of the spread of flame versus time for a material tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*. (SAF-INT) [*101*, 2018]

3.3.25 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).

3.3.26 Free of Fire Damage. The structure, system, or component under consideration that is capable of performing its intended function during and after the postulated fire, as needed.

3.3.27 High Impedance Faults. Fire-induced faults on circuits routed through a common fire area that are assumed to occur simultaneously and have a current magnitude below the trip point for the individual circuits and the sum of the currents generated by the simultaneous occurrence of such faults could trip the main circuit breaker and cause the loss of a safe shutdown power supply.

3.3.28* High-Low Pressure Interface. A valve or set of valves that separates a high pressure primary coolant system from a low pressure system.

3.3.29* Industrial Fire Brigade. An organized group of employees within an industrial occupancy who are knowledgeable, trained, and skilled in at least basic fire-fighting operations, and whose full-time occupation might or might not be the provision of fire suppression and related activities for their employer.

3.3.30 Limited-Combustible (Material). See 8.3.4.

3.3.31 Noncombustible (Material). See 8.3.4.

3.3.32 Normal Operations. All modes of nonemergency nuclear power plant operation, ranging from 0 percent to 100 percent power, which include refueling outages but do not include extended outages when fuel is removed from the reactor.

3.3.33* Nuclear Safety Function. Any function that is necessary to ensure the integrity of the reactor coolant pressure boundary; the capability to shut down the reactor and maintain it in a safe shutdown condition; or the capability to prevent or mitigate the consequences of nuclear power plant conditions that could result in the potential for a significant fraction of allowable off-site releases.

3.3.34* Nuclear Safety Related. Structures, systems, or components that are required to remain functional to ensure the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a safe shutdown condition, or the capability to prevent or mitigate the consequences of accidents that could result in potential off-site exposures comparable to regulatory guideline exposures.

3.3.35 Postulated Fire. A fire that is assumed to occur in a specific area of a nuclear plant.

3.3.36* Power Block. Structures that have equipment required for nuclear plant operations.

3.3.37 Redundant Component, System, or Subsystem. A component, system, or subsystem that independently duplicates the essential function of another component, system, or subsystem.

3.3.38 Safe Shutdown. A shutdown with the reactivity of the reactor kept subcritical as specified by the technical specifications for the unit.

3.3.39* Safety Division. The designation applied to a given system or set of nuclear safety–related components that enable the establishment and maintenance of physical, electrical, and functional independence from other redundant systems or sets of components.

3.3.40* Spurious Operation. An unwanted change in state of equipment due to fire-induced faults (e.g., hot shorts, open circuits, or shorts to ground) on its power or control circuitry.

3.3.41 Spurious Signal. A fire-induced signal that could cause the spurious operation of components or equipment that would adversely affect the safe shutdown capability.

Chapter 4 Fire Protection Program

4.1* General.

4.1.1 All elements of the site fire protection program shall be reviewed every 2 years and updated as necessary.

4.1.2 Other review frequencies shall be permitted where specified in site administrative procedures and approved by the authority having jurisdiction.

4.2 Management Policy Direction and Responsibility.

4.2.1 A policy document shall be prepared that defines management authorities and responsibilities and establishes the general policy for the site fire protection program.

4.2.2 The policy document shall designate the senior management person with immediate authority and responsibility for the fire protection program.

4.2.3 The policy document shall define the fire protection interfaces with other organizations and assign responsibilities for the coordination activities.

4.2.4 The policy document shall include the authority for conflict resolution.

4.3 Fire Prevention Program. A fire prevention program shall be established and documented to include all of the following:

(1) Fire safety information for all employees and contractors, including as a minimum familiarization with plant fire prevention procedures, fire reporting, and plant emergency alarms, including evacuation
(2) Documented plant inspections, including provisions for handling of remedial actions to correct conditions that increase fire hazards
(3) Procedures for the control of general housekeeping practices and the control of transient combustibles
(4) Procedures for the control of flammable and combustible gases in accordance with NFPA standards
(5) Procedures for the control of ignition sources, such as smoking, welding, cutting, and grinding *(see NFPA 51B)*
(6) Fire prevention surveillance plan *(see NFPA 601)*
(7) Fire-reporting procedure, including investigation requirements and corrective action requirements

4.4* Fire Hazards Analysis.

4.4.1 A documented fire hazards analysis shall be made for each site.

4.4.2 The analysis shall document all of the following:

(1) Physical construction and layout of the buildings and equipment, including fire areas and the fire ratings of area boundaries
(2)* Inventory of the principal combustibles within each fire subdivision
(3) Description of the fire protection equipment, including alarm systems and manual and automatic extinguishing systems
(4) Description and location of any equipment necessary to ensure a safe shutdown, including cabling and piping between equipment
(5) Analysis of the postulated fire in each fire area, including its effect on safe shutdown equipment, assuming automatic and manual fire protection equipment do not function
(6) Analysis of the potential effects of a fire on life safety, release of contamination, impairment of operations, and property loss, assuming the operation of installed fire-extinguishing equipment
(7) Analysis of the potential effects of other hazards, such as earthquakes, storms, and floods, on fire protection
(8) Analysis of the potential effects of an uncontained fire in causing other problems not related to safe shutdown, such as a release of contamination and impairment of operations
(9) Analysis of the postfire recovery potential
(10) Analysis for the protection of nuclear safety–related systems and components from the inadvertent actuation or breaks in a fire protection system
(11) Analysis of the smoke control system and the impact smoke can have on nuclear safety and operation for each fire area
(12) Analysis of the emergency planning and coordination requirements necessary for effective loss control, including any necessary measures to compensate for the failure or inoperability of any active or passive fire protection system or feature

4.5 Procedures. A formal procedure system for all actions pertaining to the fire protection program shall be established, including all of the following:

(1) Inspection, testing, maintenance, and operation of fire protection systems and equipment, both manual and automatic, such as detection and suppression systems
(2) Inspection, testing, and maintenance of passive fire protection features, such as fire barriers and penetration seals
(3) Trend analysis requirements
(4) Provisions for entering areas with access restrictions
(5) Training requirements

4.6 Quality Assurance.

4.6.1 A quality assurance program shall be established in accordance with ASME NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities*, for all of the following aspects of the fire protection program related to nuclear safety:

(1) Design and procurement document control
(2)* Instructions, procedures, and drawings
(3)* Control of purchased material, equipment, and services
(4)* Inspection
(5)* Test and test control
(6)* Inspection, test, and operating status
(7)* Nonconforming items
(8)* Corrective action
(9)* Records
(10)* Audits

4.6.2 The quality assurance program shall be documented in detail to verify its scope and adequacy.

4.7 Fire Emergency Plan.

4.7.1 A written fire emergency plan shall be established.

4.7.2 As a minimum, this plan shall include the following:

(1) Response to fire and supervisory alarms
(2) Notification of plant and public emergency forces
(3) Evacuation of personnel
(4) Coordination with security, maintenance, operations, and public information personnel
(5) Fire extinguishment activities
(6) Postfire recovery and contamination control activities
(7) Control room operations during an emergency
(8) Prefire plan
(9) Description of interfaces with emergency response organizations, security, safety, and others having a role in the fire protection program, including agreements with outside assistance agencies, such as fire departments and rescue services

4.8 Fire Brigade. A plant fire brigade shall be established as indicated in Chapter 6.

Chapter 5 Fire Prevention and Administrative Controls

5.1* General.

5.2 Plant Inspections.

5.2.1 The owner or a designated manager shall develop, implement, and update as necessary a fire prevention surveillance plan integrated with recorded rounds to all accessible sections of the plant.

5.2.2 Inspections of the plant shall be conducted in accordance with NFPA 601.

5.2.3 A prepared checklist shall be used for the inspection.

5.2.4 Areas of primary containment and high-radiation areas normally inaccessible during plant operation shall be inspected as plant conditions permit but at least during each refueling outage.

5.2.5 The results of each inspection shall be documented and retained for 2 years.

5.2.5.1 For those plant areas inaccessible for periods greater than 2 years, the most recent inspection shall be retained.

5.3 Control of Combustible Materials.

5.3.1* Plant administrative procedures shall specify appropriate requirements governing the storage, use, and handling of flammable and combustible liquids and flammable gases.

5.3.1.1* An inventory of all temporary flammable and combustible materials shall be made for each fire area, identifying the location, type, quantity, and form of the materials.

5.3.1.2* Temporary but predictable and repetitive concentrations of flammable and combustible materials shall be considered.

5.3.1.3 Combustibles other than those that are an inherent part of the operation shall be restricted to designated storage compartments or spaces.

5.3.1.4 Consideration shall be given to reducing the fire hazard by limiting the amount of combustible materials.

5.3.1.5 The storage and use of hydrogen shall be in accordance with NFPA 55.

5.3.1.6 The temporary use of wood shall be minimized.

5.3.1.7 Plant administrative procedures shall specify that if wood must be used in the power block, it shall be listed pressure-impregnated fire-retardant lumber.

5.3.2 Housekeeping.

5.3.2.1 Housekeeping shall be performed in such a manner as to minimize the probability of fire.

5.3.2.2 Accumulations of combustible waste material, dust, and debris shall be removed from the plant and its immediate vicinity at the end of each work shift or more frequently as necessary for safe operations.

5.3.3 Transient Combustible Loading.

5.3.3.1* Plant administrative procedures shall require the following:

(1) The total fire loads, including temporary and permanent combustible loading, shall not exceed those quantities established for extinguishment by permanently installed fire protection systems and equipment.
(2) Where limits are temporarily exceeded, the plant fire protection manager shall ensure that appropriate fire protection measures are provided.

5.3.3.2 The fire protection manager or a designated representative shall conduct weekly walk-through inspections to ensure implementation of required controls.

5.3.3.2.1 During major maintenance operations, the frequency of these walk-throughs shall be increased to daily.

5.3.3.2.2 The results of these inspections shall be documented and the documentation retained for a minimum of 2 years.

5.3.3.3 When the work is completed, the plant fire protection manager shall have the area inspected to confirm that transient combustible loadings have been removed from the area.

5.3.3.3.1 Extra equipment shall then be returned to its proper location.

5.3.3.3.2 The results of this inspection shall be documented and retained for 2 years.

5.3.3.4* Only noncombustible panels or flame-retardant tarpaulins or approved materials of equivalent fire-retardant characteristics shall be used.

5.3.3.5 Any fabrics or plastic films used, other than those complying with 5.3.3.4, shall be certified to conform to the large-scale fire test described in NFPA 701.

5.3.4 Flammable and Combustible Liquids.

5.3.4.1 Flammable and combustible liquid storage and use shall be in accordance with NFPA 30.

5.3.4.2 Where oil-burning equipment, stationary combustion engines, or gas turbines are used, they shall be installed and used in accordance with NFPA 31 or NFPA 37 as appropriate.

5.3.4.3 Flammable and combustible liquid and gas piping shall be in accordance with ASME B31.1, *Power Piping*, or *ASME Boiler and Pressure Vessel Code*, Section III, as applicable.

5.3.4.4 Hydraulic systems shall use only listed fire-resistant hydraulic fluids, except as specified by 5.3.4.5.

5.3.4.5 Where unlisted hydraulic fluids must be used, they shall be protected by a fire suppression system.

5.3.4.6 The ignition of leaked or spilled liquid shall be minimized by the following methods:

(1)* Keeping the liquid from contact with hot parts of the steam system (wall temperature greater than or equal to ignition temperature), such as steam pipes and ducts, entry valve, turbine casing, reheater, and bypass valve
(2) Using suitable electrical equipment
(3) Sealing the insulation of hot plant components to prevent liquid saturation
(4) Using concentric piping
(5) Using liquid collection systems

5.4 Control of Ignition Sources.

5.4.1 Plant Administrative Procedures.

5.4.1.1 Plant administrative procedures shall require an in-plant review and prior approval of all work plans to assess potential fire hazard situations.

5.4.1.2 Where potential fire hazards are determined to exist, special precautions shall be taken to define appropriate conditions under which the work is authorized.

5.4.2 Hot Work.

5.4.2.1 The owner or a designated manager shall develop, implement, and update as necessary a welding and cutting safety procedure using NFPA 51B and NFPA 241 as a guide.

5.4.2.2 Written permission from the fire protection manager or a designated alternate shall be obtained before starting activities involving cutting, welding, grinding, or other potential ignition sources.

5.4.2.3* A permit shall not be issued until all of the following are accomplished:

(1) An inspection has determined that hot work can be conducted at the desired location.
(2) Combustibles have been moved away or covered.
(3) The atmosphere is nonflammable.
(4) A trained fire watch (with equipment) is posted for the duration of the work and for 30 minutes thereafter, to protect against sparks or hot metal starting fires.

5.4.2.4 All cracks or openings in floors shall be covered or closed.

5.4.3 Smoking.

5.4.3.1 Smoking shall be prohibited at or in the vicinity of hazardous operations or combustible and flammable materials.

5.4.3.2 "No Smoking" signs shall be posted in the areas specified in 5.4.3.1.

5.4.3.3 Smoking shall be permitted only in designated and supervised safe areas of the plant.

5.4.3.4 Where smoking is permitted, safe receptacles shall be provided for smoking materials.

5.4.4 Temporary Electrical Wiring. All temporary electrical wiring shall comply with the following to minimize the ignition of flammable materials:

(1) Be kept to a minimum
(2) Be suitable for the location
(3) Be installed and maintained in accordance with *NFPA 70* or ANSI/IEEE C2, *National Electrical Safety Code*, as appropriate
(4) Be arranged so that energy shall be isolated by a single switch
(5) Be arranged so that energy shall be isolated when not needed

5.4.5 Temporary Heating Appliances.

5.4.5.1 Only safely installed, approved heating devices shall be used in all locations.

5.4.5.2 Ample clearance shall be provided around stoves, heaters, and all chimney and vent connectors to prevent ignition of adjacent combustible materials in accordance with NFPA 211 (connectors and solid fuel); NFPA 54 (fuel gas appliances); and NFPA 31 (liquid fuel appliances).

5.4.5.3 Refueling operations of heating equipment shall be conducted in an approved manner.

5.4.5.4 Heating devices shall be situated so that they are not likely to overturn.

5.4.5.5 Temporary heating equipment, when utilized, shall be monitored and maintained by properly trained personnel.

5.4.6 Open-flame or combustion-generated smoke shall not be used for leak testing.

5.4.7 Plant administrative procedures shall specify appropriate requirements governing the control of electrical appliances in all plant areas.

5.5 Temporary Structures.

5.5.1 Exterior Buildings.

5.5.1.1* Temporary buildings, trailers, and sheds, whether individual or grouped, shall be constructed of noncombustible material and shall be separated from other structures.

5.5.1.2 Temporary buildings, trailers, and sheds and other structures constructed of combustible or limited-combustible material shall be separated from other structures by a minimum distance of 30 ft (9.1 m), unless otherwise permitted by 5.5.1.3.

5.5.1.3 Where all portions of the exposed building (walls, roof) within 30 ft (9.1 m) of the exposure constitute a rated fire barrier, the minimum separation distance shall be permitted to be reduced in accordance with Table 5.5.1.3.

Table 5.5.1.3 Minimum Separation Distances

Exposed Building Fire Barrier Rating (hr)	Exposing Building Without Sprinkler Protection		Exposing Building with Automatic Sprinklers	
	ft	m	ft	m
3	5	1.5	0	0
2	10	3.0	5	1.5
1	20	6.1	10	3.0
<1	30	9.1	15	4.6

5.5.1.4 All exterior buildings, trailers, sheds, and other structures shall have the appropriate type and size of portable fire extinguishers.

5.5.2 Exterior Temporary Coverings. Where coverings are utilized for protection of the outdoor storage of materials or equipment, the following shall apply:

(1) Only approved fire-retardant tarpaulins or other acceptable materials shall be used.
(2) All framing material used to support such coverings shall be either noncombustible or fire-retardant pressure-impregnated wood.
(3) Covered storage shall not be located within 30 ft (9.1 m) of any building.

5.5.3 Interior Temporary Facilities.

5.5.3.1 All interior temporary structures shall be constructed of noncombustible, limited-combustible, or fire-retardant pressure-impregnated wood.

5.5.3.1.1 Structures constructed of noncombustible or limited-combustible materials shall be protected by an automatic fire suppression system unless the fire hazard analysis determines that automatic suppression is not required.

5.5.3.1.2 The structure shall be protected by an automatic fire suppression system if the structure is constructed of fire-retardant pressure-impregnated wood.

5.5.3.2 The use of interior temporary coverings shall comply with the following criteria:

(1) Be limited to special conditions where interior temporary coverings are necessary
(2) Be constructed of approved fire-retardant tarpaulins

5.5.3.3 Where framing is required, it shall be constructed of noncombustible, limited-combustible, or fire-retardant pressure-impregnated wood.

5.5.3.4 All interior temporary facilities shall have the appropriate type and size of portable fire extinguisher.

5.6 Impairments.

5.6.1* A written procedure shall be established to address impairments to fire protection systems and features and other plant systems that directly affect the level of fire risk (e.g., ventilation systems, plant emergency communication systems).

5.6.2* Impairments to fire protection systems shall be as short in duration as practical.

5.6.3* Appropriate postmaintenance testing shall be performed on equipment that was impaired to ensure that the system will function properly.

5.6.4 Any change to the design or function of the system after the impairment shall be considered in establishing the testing requirements and shall be reflected in the appropriate design documents and plant procedures.

5.7 Testing and Maintenance.

5.7.1 Upon installation, all new fire protection systems and passive fire protection features shall be preoperationally inspected and tested in accordance with applicable NFPA standards.

5.7.2 Where appropriate test standards do not exist, inspections and test procedures described in the purchase and design specification shall be followed.

5.7.3* Fire protection systems and passive fire protection features shall be inspected, tested, and maintained in accordance with applicable NFPA standards, manufacturers' recommendations, and requirements established by those responsible for fire protection at the plant.

5.7.4 Inspection, testing, and maintenance shall be performed using established procedures with written documentation of results and a program of follow-up actions on discrepancies.

5.7.5* Consideration shall be given to the inspection, testing, and maintenance of non–fire protection systems and equipment that have a direct impact on the level of fire risk within the plant.

5.7.6* Integrated fire protection systems shall be tested in their entirety from end to end.

Chapter 6 Manual Fire Fighting

6.1 Prefire Plans.

6.1.1 Detailed prefire plans shall be developed for all site areas.

6.1.2* Prefire plans shall detail the fire area configurations and fire hazards to be encountered in the fire area along with any safety-related components and fire protection systems and features that are present.

6.1.3 Prefire plans shall be reviewed and, if necessary, updated at least every 2 years.

6.1.4* Prefire plans shall be available in the control room and made available to the plant fire brigade.

6.2* On-Site Fire-Fighting Capability.

6.2.1 General.

6.2.1.1 A minimum of five plant fire brigade members shall be available for response at all times.

6.2.1.2 Fire brigade members shall have no other assigned normal plant duties that would prevent immediate response to a fire or other emergency as required.

6.2.1.3 The brigade leader and at least two brigade members shall have training and knowledge of plant safety–related systems to understand the effects of fire and fire suppressants on safe shutdown capability.

6.2.1.4 The fire brigade shall be notified immediately upon verification of a fire or fire suppression system actuation.

6.2.2 Fire Fighter Qualifications and Requirements.

6.2.2.1 Plant fire brigade members shall be physically qualified to perform the duties assigned.

6.2.2.2 Each member shall pass an annual physical examination to determine that the fire brigade member can perform strenuous activity.

6.2.2.3 The physical examination shall determine each member's ability to use respiratory protection equipment.

6.2.3 Each fire brigade member shall meet training qualifications as specified in Section 6.3.

6.3 Training and Drills.

6.3.1 Plant Fire Brigade Training.

6.3.1.1 Plant fire brigade members shall receive training consistent with the requirements contained in NFPA 600 or NFPA 1500 as appropriate.

6.3.1.2* Fire brigade members shall be given quarterly training and practice in fire fighting.

6.3.1.3 A written program shall detail the fire brigade training program.

6.3.1.4 Written records that include but are not limited to the following shall be maintained for each fire brigade member:

(1) Initial fire brigade classroom and hands-on training
(2) Refresher training
(3) Special training schools attended
(4) Drill attendance records
(5) Leadership training for fire brigades

6.3.2 Drills.

6.3.2.1 Drills shall be conducted quarterly for each shift to test the response capability of the fire brigade.

6.3.2.2 Fire brigade drills shall be developed to test and challenge fire brigade response, including the following:

(1) Brigade performance as a team
(2) Proper use of equipment
(3) Effective use of prefire plans
(4) Coordination with other groups

6.3.2.3 Fire brigade drills shall be conducted in various plant areas, especially in those areas identified by the fire hazards analysis to be critical to plant operation and to contain significant fire hazards.

6.3.2.4 Drill records shall be maintained detailing the drill scenario, fire brigade member response, and ability of the fire brigade to perform the assigned duties.

6.3.2.5 A critique shall be held after each drill.

6.4 Fire-Fighting Equipment.

6.4.1* The plant fire brigade shall be provided with equipment that enables its members to adequately perform their assigned tasks.

6.4.2 Fire brigade equipment shall be tested and maintained.

6.4.3 Written records shall be retained for review.

6.5 Off-Site Fire Department Interface.

6.5.1 Mutual Aid Agreement.

6.5.1.1 A mutual aid agreement shall be offered to the local off-site fire department.

6.5.1.2 Where possible, the plant fire protection manager and the off-site fire authorities shall develop a plan for their interface.

6.5.1.3 The fire protection manager also shall consult with the off-site fire department to make plans for fire fighting and rescue, including assistance from other organizations, and to maintain these plans.

6.5.1.4 The local off-site fire department shall be invited to participate in an annual drill.

6.5.2 Site-Specific Training.

6.5.2.1 Fire fighters from the off-site fire department who are expected to respond to a fire at the plant shall be familiar with the plant layout.

6.5.2.2 The access routes to fires in the controlled area (to which access doors are locked) shall be planned in advance.

6.5.2.3* The off-site fire department shall be offered instruction and training in radioactive materials, radiation, and hazardous materials that could be present.

6.5.3 Security and Health Physics.

6.5.3.1* Plant management shall designate a plant position to act as a liaison to the off-site fire department when it responds to a fire or other emergency at the plant.

6.5.3.2 Plant management shall ensure that the off-site fire department personnel are escorted at all times and emergency actions are not delayed.

6.6 Water Drainage. The fire brigade shall have at its disposal the necessary equipment to assist with routing water from the affected area.

6.7 Fire-Fighting Access.

6.7.1 All plant areas shall be accessible for fire-fighting purposes.

6.7.2 Prefire plans shall identify those areas of the plant that are locked and have limited access for either security or radiological control reasons.

6.7.2.1 Provisions shall be made to allow access to the locked areas, including having security and health physics personnel respond to the fire area along with the fire brigade, if necessary.

6.7.2.2 Health physics personnel shall confer with the fire brigade leader to determine the safest method of access to any radiologically controlled area.

6.8 Radiation Shielding.

6.8.1 Full advantage shall be taken of all fixed radiation shielding to protect personnel responding for fire suppression purposes.

6.8.2 Health physics personnel shall advise the fire brigade leader of the best method for affording radiological protection.

6.9* Smoke and Heat Removal. If fixed ventilation systems are not capable of removing smoke and heat, the fire brigade shall utilize portable ventilation equipment. *(See Section 8.4.)*

Chapter 7 Nuclear Reactor Safety Considerations

7.1* General.

7.2 Fire-Safe Shutdown Analysis (FSSA). A fire-safe shutdown analysis (FSSA) shall be prepared and maintained for the operating life of the reactor and shall include, as a minimum, all of the following:

(1) Fire hazards analysis (FHA)
(2) Safe shutdown analysis (SSA)
(3) Internal plant examination of external fire events for severe accident vulnerabilities

7.2.1 Fire Hazards Analysis. The fire hazards analysis shall include the criteria indicated in Section 4.4.

7.2.2 Safe Shutdown Analysis. A safe shutdown analysis of the effects of a fire on those essential structures, systems, and components required to safely shut down the plant and maintain it in a safe shutdown condition shall be performed, including, as a minimum, the requirements of this section.

7.2.2.1 A safe shutdown system available/unavailable calculation or table that provides the following shall be prepared and maintained for each fire area:

(1) The document shall identify all safe shutdown equipment that is operable or inoperable due to the effects of a fire in that fire area.
(2) The document shall demonstrate compliance with the requirements of Sections 7.3 and 7.4.

7.2.2.2* A shutdown logic diagram shall be available that identifies the conditions necessary to achieve and maintain safe shutdown capability in the event of a fire and the plant features necessary to realize those conditions, including auxiliary and support features.

7.2.3 Internal Plant Examination of External Fire Events for Severe Accident Vulnerabilities. A risk assessment that estimates the potential risk from a fire in relation to the plant's core damage frequency shall be prepared.

7.2.3.1* An industry-accepted examination process shall be used for the risk assessment.

7.2.3.2* An acceptable risk assessment shall demonstrate that the probability of core damage as a result of an internal fire is less than 1×10^{-6} per reactor year.

7.2.3.3 The internal plant examination of external fire events for severe accident vulnerabilities shall be used to evaluate the level of safety of the plant and shall not be used to reduce the overall plant fire protection design basis.

7.3 Design Basis Events and Requirements.

7.3.1 Fire.

7.3.1.1 Only one fire shall be assumed to occur at a given time, and for the purpose of a safe shutdown analysis, damage shall be assumed to occur immediately.

7.3.1.2* All components, including electrical cables, that are susceptible to fire damage in a single fire area (except primary containment and annulus areas) shall be assumed to be disabled or to be spuriously actuated, whichever is the worse case.

7.3.1.3* A fire shall not impair safe shutdown capability inside primary containment or annulus areas.

7.3.1.4 The plant shall be assumed to be operating at 100 percent power, with all components in their normal configuration, when a postulated fire occurs; however, the analysis also shall consider changes in plant configurations during all normal modes of operation.

7.3.1.5 A concurrent single active component failure independent of the postulated fire shall not be assumed to occur.

7.3.1.6 Plant accidents or severe natural phenomena shall not be assumed to occur concurrently with a postulated fire, except as specified in 7.3.2.

7.3.1.7 A loss of off-site power shall be assumed concurrent with the postulated fire only where the safe shutdown analysis (including alternative shutdown) indicates the fire could initiate the loss of off-site power.

7.3.1.8* Fire-safe shutdown components shall be capable of performing all the following functions in the event of the postulated fire:

(1) Achieving and maintaining subcritical reactivity conditions in the reactor
(2) Maintaining the reactor coolant inventory such that plant safety limits are not violated
(3) Establishing reactor decay heat removal to prevent fuel damage and to achieve and maintain cold shutdown conditions
(4) Providing support functions such as process cooling and lubrication necessary to allow operation of the FSSD components
(5) Providing direct readings of the process variables necessary to perform and control the FSSD functions

7.3.1.9 Limiting Safety Conditions. During a postfire shutdown, the fission product boundary integrity shall be maintained within acceptable limits (e.g., fuel clad damage, rupture of any primary coolant boundary, or rupture of the primary containment boundary).

7.3.1.10 Spurious Signals.

7.3.1.10.1 An evaluation of spurious signals shall be performed based on the following:

(1) All components shall be assumed to be in their normal operating positions for the particular mode of operation being considered by the spurious signal evaluation.
(2) The evaluation shall consider the following cable failure modes:
    (a) A hot short in which individual conductors within a cable are shorted to individual conductors of a different cable such that a de-energized circuit might become energized by shorting to an external source of electrical power
    (b) An open circuit in which the cable failure results in the loss of electrical continuity
    (c) A short to ground in which a cable conductor shorts to grounded structures
    (d) A short circuit in which individual conductors within multiconductor cable short to each other

7.3.1.10.2 Functional failure or damage modes of equipment and components that can spuriously operate shall be considered.

7.3.1.11 Fire-Induced Spurious Actuation. The postulates specified in 7.3.1.11.1 through 7.3.1.11.5 shall be used in the analysis of fire-induced spurious actuation of equipment.

7.3.1.11.1 FSSD capability shall not be adversely affected by simultaneous spurious actuation of all valves in a single high-to-low pressure interface line where the power or control circuits for the valves can be damaged by a postulated fire.

7.3.1.11.2 For other than high-to-low pressure boundaries, FSSD capability shall not be adversely affected by spurious actuation or signal.

7.3.1.11.3 Separate conditions shall be analyzed concurrent with the spurious actuation(s) or signal addressed in 7.3.1.11.1 and 7.3.1.11.2.

7.3.1.11.4 All automatic functions (signal, logic, etc.) from the circuits that can be damaged by the postulated fire shall be assumed lost or assumed to function as intended, whichever is the worse case.

7.3.1.11.5 Potential spurious signals shall be analyzed in accordance with NEI 00-01, *Guidance for Post-Fire Safe Shutdown Circuit Analysis.*

7.3.1.12* For the purpose of analysis for cases involving high-to-low pressure interface, hot shorts involving three-phase ac circuits shall be postulated.

7.3.1.13 For ungrounded dc circuits, if it can be shown that only two hot shorts of the proper polarity without grounding could cause spurious operation, no further evaluation shall be necessary, except for cases involving high-to-low pressure interfaces.

7.3.1.14* Circuits Associated by Common Power Supply. All common power supply–associated circuits of concern shall be isolated from FSSD circuits by coordinated circuit breakers or fuses.

7.3.1.15* Circuits Associated by Common Enclosure.

7.3.1.15.1 Protection for circuits associated by common enclosure shall meet the following criteria:

(1) Protection shall be demonstrated by ensuring that suitable electrical overcurrent protection devices are provided for all cables.
(2) Appropriate measures to prevent the propagation of fire, such as rated fire stops and seals in the raceway or enclosure, shall be provided.

7.3.1.15.2 The overcurrent protection devices specified in 7.3.1.15.1(1) shall be located outside the fire area containing the common enclosure.

7.3.1.16 High-Impedance Faults.

7.3.1.16.1 A high-impedance fault shall be assumed to occur as a result of a fire.

7.3.1.16.2 Evaluation of the impact of high-impedance faults on the ability to achieve and maintain safe shutdown shall be performed to demonstrate that sufficient capacity exists in the electrical protective system to preclude a trip of the main source breaker to the supply.

7.3.2* Seismic/Fire Interaction.

7.3.2.1 A risk assessment that demonstrates the potential risk from a seismically induced fire in relationship to the plant's core damage frequency shall be prepared and used as follows:

(1) The assessment shall be used to evaluate the level of safety of the plant.
(2) The assessment shall not be used to reduce the overall plant fire protection design basis.

7.3.2.2* An industry-accepted examination process shall be used for the risk assessment.

7.4 Separation Criteria.

7.4.1 One safety division of systems that is necessary to achieve and maintain safe shutdown from either the control room or emergency control station(s) shall be maintained free of fire damage by a single fire, including an exposure fire.

7.4.2 One safety division of systems that is necessary to prevent the initiation of a design basis accident shall be maintained free of fire damage from a single fire that occurs outside the main control room.

7.4.3 Redundant cables, equipment, components, and associated circuits of nuclear safety–related or safe shutdown systems shall be located in separate fire areas, unless otherwise permitted by 7.4.3.1.

7.4.3.1 Where redundant system separation inside containment cannot be achieved, other measures shall be permitted in accordance with Section 7.6 to prevent a fire from causing the loss of function of nuclear safety–related or safe shutdown systems.

7.4.3.2 The fire barrier forming the separate fire areas specified in 7.4.3 shall have a 3-hour fire rating, and automatic area-wide detection shall be installed throughout the fire areas, unless all the following criteria are met:

(1) The fire barriers forming the fire areas shall have a minimum fire-resistive rating of 1 hour.
(2) Automatic area-wide detection and suppression shall be installed throughout the fire areas.
(3) Structural steel forming a part of or supporting the fire barriers shall be protected to provide fire resistance equivalent to that of the barrier.

7.4.3.3 Structural steel forming a part of or supporting the fire barriers shall be protected to provide fire resistance equivalent to that of the 3-hour fire-rated barrier specified in 7.4.3.2.

7.4.4 Fire areas separated by minimum 3-hour fire-rated barriers shall be established to separate redundant safety divisions and safe shutdown functions from fire hazards in nonsafety or safe shutdown–related areas of the plant.

7.4.5 In fire areas containing components of either a nuclear safety–related or safe shutdown system, special attention shall be given to detecting and suppressing fire that can adversely affect the system.

7.4.6 Measures that shall be taken to reduce the effects of a postulated fire in a given fire area include the following:

(1) Limiting the amount of combustible materials *(see Section 5.3)*

(2) Providing fire-rated barriers between major components and equipment to limit fire spread within a fire area *(see Section 8.1)*
(3) Installing fire detection *(see Section 9.8)* and fixed suppression systems *(see Section 9.6)*

7.5 Manual Actions.

7.5.1 Shutdown Procedures. Procedures shall be developed for actions necessary to achieve FSSD.

7.5.2 Operator Actions.

7.5.2.1 Operator actions necessary to achieve FSSD of the reactor shall meet criteria acceptable to the AHJ.

7.5.2.2* No credit shall be taken for operator actions required to effect repairs to equipment to achieve FSSD of the reactor.

7.5.2.3 Personnel necessary to achieve and maintain the plant in FSSD following a fire shall be provided from the normal onsite staff, exclusive of the fire brigade.

7.5.2.4 The operator training program shall include performance-based simulator training on FSSD procedures.

7.5.2.5 Walk-through of operator actions necessary to achieve FSSD of the reactor shall be performed to verify that the actions are feasible and shall be integrated into the operator training program.

7.5.2.6 Postfire shutdown and recovery plans shall be included in the station emergency preparedness plan.

7.5.2.7 Drills and operator requalification training shall ensure that operations personnel are familiar with and can accomplish the necessary actions.

7.5.3 Operator Access and Equipment Operation.

7.5.3.1 Operator Access.

7.5.3.1.1* Access routes to areas containing equipment necessary for safe shutdown of the reactor shall be protected from the effects of smoke and fire.

7.5.3.1.2 Two separate access routes shall be provided from the main control room to the remote shutdown location.

7.5.3.1.3 Emergency lighting shall be provided for the access routes and the remote shutdown location *(see Section 8.6)*.

7.5.3.2 Equipment Operation.

7.5.3.2.1* Operator safety shall not be threatened by fire conditions while FSSD of the reactor is being implemented.

7.5.3.2.2* Operation of equipment required to effect FSSD of the reactor shall not require any extraordinary actions by the operator.

7.5.3.2.3 Operators (e.g., handwheels of valves that require manual manipulation for FSSD) shall be readily accessible.

7.5.3.2.3.1 If the handwheel is located more than 5 ft (1.5 m) above the floor, it shall be provided with either a chain operator or a permanent platform.

7.5.3.2.3.2 The platform shall be of sufficient size to allow the operator to safely perform the manual action.

7.6 Alternative Shutdown Capability.

7.6.1 Alternative shutdown capability provided for a specific fire area shall include the following:

(1) Achieving and maintaining subcritical reactivity conditions in the reactor
(2) Maintaining the reactor coolant inventory
(3) Achieving safe shutdown
(4) Maintaining safe shutdown following the fire event

7.6.2 During the postfire shutdown, the reactor coolant system process variables shall be maintained within those values predicted for a loss of normal ac power, and the fission product boundary integrity shall not be affected.

7.6.3 Performance goals for reactor shutdown functions shall be the same as those required by 7.3.1.8.

7.6.4 The safe shutdown circuits for each fire area shall meet the following criteria:

(1) They shall be known to be isolated from associated circuits in the fire area so the hot shorts, shorts to ground, open circuits, or short circuits will not prevent the operation of the safe shutdown equipment.
(2) Isolation of associated circuits from the safe shutdown equipment shall be such that a postulated fire involving the associated circuits will not prevent safe shutdown or damage the safe shutdown components.

Chapter 8 General Plant Design

8.1 Plant Arrangement.

8.1.1 Building Separation.

8.1.1.1 In multiunit plants, each unit shall be separated from adjacent units by either an open space of at least 50 ft (15.2 m) or at least a 3-hour-rated fire barrier.

8.1.1.2 Buildings or portions thereof containing nuclear safety–related systems shall be separated from buildings or portions thereof not related to nuclear safety by barriers having a designated fire resistance rating of 3 hours.

8.1.1.3 Buildings containing nuclear safety–related systems shall be permitted to be separated from buildings not related to nuclear safety by an open space of at least 50 ft (15.2 m).

8.1.2 Fire Areas.

8.1.2.1 Advanced light water reactor (ALWR) electric generating plants shall be subdivided into separate fire areas to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat, radioactive contamination, and fire-fighting activities.

8.1.2.2 In addition to 8.1.2.1, the subdivision into fire areas shall allow adequate access for manual fire suppression activities.

8.1.2.3 A listed fire barrier having a fire resistance rating of at least 3 hours and with listed 3-hour-rated penetration seals shall be provided as follows:

(1) To separate all contiguous buildings or portions thereof serving different purposes, such as reactor containment, auxiliary, turbine, rad waste, control, service, administration, and other occupancy areas as dictated by reactor design

(2) To separate safety-related standby emergency diesel generators and combustion turbines from each other and the rest of the plant
(3) To separate the turbine generator lube oil conditioning system and lube oil storage from the turbine building and adjacent areas
(4) To separate diesel fire pumps and associated equipment from other pumps in the same pump house
(5) To separate all areas with heavy concentrations of cables, such as cable spreading rooms, cable tunnels, cable penetration areas, and cable shafts or chases, including those within the reactor containment, from adjacent areas
(6) To separate auxiliary boiler rooms from adjacent areas
(7) Wherever so determined by the fire hazards analysis

8.1.2.4 To prevent vertical spread of fire, stairways, elevator shafts, trash chutes, and other vertical shafts and plenums shall be enclosed with barriers having a fire resistance rating of at least 2 hours.

8.1.2.5 Openings in the barriers specified in 8.1.2.4 shall be protected with listed automatic or self-closing fire doors having a fire protection rating of at least 1½ hours.

8.1.3 Openings in Fire Barriers.

8.1.3.1 All openings in fire barriers shall be provided with fire door assemblies, fire dampers, penetration seals (fire stops), or other approved means having a fire protection rating consistent with the designated fire resistance rating of the barrier, unless the criterion of 8.1.3.2 is met.

8.1.3.2 Assemblies used to meet the requirements of 8.1.3.1 that are not listed or approved due to nuclear safety or security requirements shall be demonstrated to be equivalent.

8.1.3.3 Fire door assemblies, fire dampers, and fire shutters used in 2-hour-rated fire barriers shall be listed as not less than 1½-hour rated and shall meet the requirements of NFPA 80 for fire door requirements and NFPA 90A for fire damper requirements, unless otherwise permitted by 8.1.3.4.

8.1.3.4 Where approved full-scale fire tests indicate that opening protection is not necessary, the opening protection specified in 8.1.3.3 shall not be required.

8.1.3.4.1 Windows in fire barriers, such as for a control room or computer room, shall be provided with a listed or approved fire shutter or automatic wall curtain.

8.1.3.4.2 Cable openings, piping openings, and building joints shall be provided with fire-rated penetration seals that meet the requirements of ASTM E814, *Standard Method for Fire Tests of Penetration Firestop Systems*, or UL 1479, *Standard for Safety Fire Tests of Through-Penetration Firestops*.

8.1.3.4.3 Internal Conduit Seals. All conduits shall be sealed at the barrier with a fire-rated seal, if accessible.

8.1.3.4.3.1 As an alternative to 8.1.3.4.3, internally sealing with a fire-rated seal at the first break in the conduit on both sides of the barrier shall be acceptable.

8.1.3.4.3.2 For the configuration specified in 8.1.3.4.3.1, the fire rating of the internal conduit seal shall be equivalent to the rating of the fire barrier being penetrated.

8.1.3.4.3.3 Where approved full-scale fire tests indicate that internal conduit seals are not necessary, internal conduit seals shall not be required.

8.1.3.4.4 All fire-rated assemblies shall be tested with a positive pressure in the furnace.

8.1.3.4.5 Normally closed fire doors in fire barriers shall be identified with a sign indicating "Fire Door — Keep Closed."

8.1.3.5 Design features that provide for monitoring and control of fire doors to ensure fire door operability and fire barrier integrity shall be provided, unless otherwise permitted by 8.1.3.6.

8.1.3.6 Administrative procedures shall be permitted to be used instead of the design features required by 8.1.3.5.

8.2 Life Safety.

8.2.1* NFPA *101* shall be the standard for life safety from fire in the design and operation of the ALWR, except where modified by this standard.

8.2.2* The majority of the areas involved in the transfer of nuclear energy to electrical energy shall be considered as special-purpose industrial occupancies and special-structure windowless buildings, as defined in NFPA *101*.

8.2.3 In determining the exits for an ALWR plant, the actual number of personnel and occupancy hazards during maintenance, refueling, and testing shall determine the exit requirements and occupant load based on NFPA *101*.

8.2.4 Cafeterias, lunchrooms, conference rooms, and assembly rooms having an occupant load greater than 50 shall conform to the new assembly occupancy requirements in NFPA *101*.

8.2.5 General office areas, office buildings, and training facilities shall conform to the business occupancy requirements in NFPA *101*.

8.2.6 Warehouses and storage areas shall conform to the storage occupancy requirements in NFPA *101*.

8.3 Building and Construction Materials.

8.3.1 Construction materials for the ALWR plant shall be classified by at least one of the following test methods appropriate to the end-use configuration of the material:

(1) NFPA 220, *Standard on Types of Building Construction*
(2) ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*
(3) ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*
(4) NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*
(5) NFPA 259, *Standard Test Method for Potential Heat of Building Materials*
(6) UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*

8.3.2* All walls, floors, and structural components, except interior finish materials, shall be of noncombustible construction.

8.3.2.1 Interior wall or ceiling finish classification shall be in accordance with NFPA *101* requirements for Class A material.

8.3.2.2 Interior floor finish classification shall be in accordance with NFPA *101* requirements for Class I interior floor finish.

8.3.3 Thermal insulation materials, radiation shielding materials, ventilation duct materials, soundproofing materials, and suspended ceilings, including light diffusers and their supports, shall be noncombustible or limited combustible.

8.3.4 Materials

8.3.4.1* Noncombustible Material. [*101*:4.6.13]

8.3.4.1.1 A material that complies with any of the following shall be considered a noncombustible material:

(1)* A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat

(2) A material that is reported as passing ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*

(3) A material that is reported as complying with the pass/fail criteria of ASTM E136 when tested in accordance with the test method and procedure in ASTM E2652, *Standard Test Method for Behavior of Materials in a Tube Furnace with a Cone-Shaped Airflow Stabilizer, at 750°C*

[*101*:4.6.13.1]

8.3.4.1.2 Where the term *limited-combustible* is used in this document, it shall also include the term *noncombustible*. [*101*:4.6.13.2]

8.3.4.2* Limited-Combustible Material. A material shall be considered a limited-combustible material where one of the following is met:

(1) The conditions of 8.3.4.2.1 and 8.3.4.2.2, and the conditions of either 8.3.4.2.3 or 8.3.4.2.2, shall be met.

(2) The conditions of 8.3.4.2.5 shall be met. [*101*:4.6.14]

8.3.4.2.1 The material shall not comply with the requirements for noncombustible material in accordance with 8.3.4.1. [*101*:4.6.14.1]

8.3.4.2.2 The material, in the form in which it is used, shall exhibit a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg) where tested in accordance with NFPA 259. [*101*:4.6.14.2]

8.3.4.2.3 The material shall have the structural base of a noncombustible material with a surfacing not exceeding a thickness of ⅛ in. (3.2 mm) where the surfacing exhibits a flame spread index not greater than 50 when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*. [*101*:4.6.14.3]

8.3.4.2.4 The material shall be composed of materials that, in the form and thickness used, neither exhibit a flame spread index greater than 25 nor evidence of continued progressive combustion when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, and shall be of such composition that all surfaces that would be exposed by cutting through the material on any plane would neither exhibit a flame spread index greater than 25 nor exhibit evidence of continued progressive combustion when tested in accordance with ASTM E84 or ANSI/UL 723. [*101*:4.6.14.4]

8.3.4.2.5 Materials shall be considered limited-combustible materials where tested in accordance with ASTM E2965, *Standard Test Method for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter*, at an incident heat flux of 75 kW/m^2 for 20-minute exposure and both of the following conditions are met:

(1) The peak heat release rate shall not exceed 150 kW/m^2 for longer than 10 seconds.

(2) The total heat released shall not exceed 8 MJ/m^2. [*101*:4.6.14.5]

8.3.4.2.6 Where the term *limited-combustible* is used in this document, it shall also include the term *noncombustible*. [*101*:4.6.14.6]

8.3.5 Electrical. Wiring above suspended ceilings shall be listed for plenum use, routed in armored cable, routed in metallic conduits, or routed in cable trays with solid metal top and bottom covers.

8.3.6 Roof coverings shall be Class A as determined by tests.

8.3.7 Metal roof deck construction shall be Class I as listed by Factory Mutual or fire acceptable as listed by Underwriters Laboratories Inc.

8.3.8 Bulk flammable gas storage, either compressed or cryogenic, shall not be permitted inside structures housing safety-related systems.

8.3.8.1 Storage of flammable gas, such as hydrogen, shall be located outdoors or in separate detached buildings, so that a fire or explosion will not adversely affect any safety-related systems or equipment.

8.3.8.2* Outdoor high-pressure flammable gas storage containers shall be located so that the long axis is not pointing at the building walls.

8.3.9 The following requirements shall apply to bulk storage of flammable and combustible liquids:

(1) Storage shall not be permitted inside structures housing safety-related systems.

(2) As a minimum, the storage and use shall comply with the requirements of NFPA 30.

8.4* Ventilation.

8.4.1* The design, installation, and operation of ventilation systems necessary for normal and emergency operation of the plant shall be in accordance with NFPA 90A.

8.4.2* Automatic damper closure or shutdown of ventilation systems shall be consistent with nuclear safety and the safety of on-site personnel.

8.4.3 Smoke removal shall be provided for nuclear safety–related areas of the plant, and the following criteria also shall apply:

(1) Equipment shall be suitable for removing smoke without damage to equipment.

(2) The release to the environment of smoke containing radioactive materials shall be monitored in accordance with emergency plans.

(3) For those plants provided with complete automatic sprinkler protection, fixed ventilation systems for the removal of smoke shall not be required.

8.4.3.1 Smoke and heat removal systems shall be provided for other fire areas based on the fire hazards analysis, unless otherwise permitted by 8.4.3.2.

8.4.3.2 For those plants provided with complete automatic sprinkler protection, fixed ventilation systems for the removal of smoke shall not be required.

8.4.3.3 Smoke from nonnuclear areas shall be discharged directly outside to an area that will not adversely affect nuclear safety–related areas.

8.4.3.4* Any ventilation system designed to exhaust potentially radioactive smoke or heat shall be evaluated to ensure that inadvertent operation or single failures will not violate the radiologically controlled areas of the plant.

8.4.4 To facilitate manual fire fighting, smoke control shall be provided in high-density cable-use areas, switchgear rooms, diesel fuel oil storage areas, turbine buildings, and other areas where potential exists for heavy smoke and heat conditions as determined by the fire hazards analysis.

8.4.5 The power supply and controls for mechanical ventilation systems used for smoke removal shall be routed outside the fire area served by the system or protected from fire damage.

8.4.6* The fresh air supply intakes to plant areas shall be located remote from the exhaust air outlets and smoke vents of other fire areas.

8.4.7 Where natural-convection ventilation is used, a minimum ratio of vent area to floor area shall be at least 1 to 200, except in oil hazard areas, where at least a 1-to-100 ratio shall be provided.

8.4.8 Duct Systems.

8.4.8.1 Combustible ducts, including fire-retardant types, shall not be used for ventilation systems.

8.4.8.2* Fire dampers shall be installed in accordance with NFPA 90A. Consideration shall be given to the velocity in the duct.

8.4.8.2.1 Where full-scale fire tests that are conducted by testing laboratories indicate that fire dampers are not necessary to prevent fire spread through a fire-rated barrier, fire dampers shall be permitted to be omitted from the fire barrier.

8.4.8.2.2 As an alternative to fire dampers, the duct system shall be permitted to be enclosed or constructed to provide the required fire barrier through adjacent areas. *(Refer to Figure A.8.4.8.2.)*

8.4.8.3 Listed fire dampers having a rating of 1½ hours shall be installed where ventilation ducts penetrate fire barriers having a required fire resistance rating of 2 hours.

8.4.8.4 Approved fire dampers having a fire protection rating of 3 hours shall be installed where ventilation ducts penetrate required 3-hour fire barriers.

8.4.8.5 Fire dampers shall be equipped for automatic closure by thermal release elements, and one of the following criteria shall be met:

(1) The fire damper shall be mounted directly into the separating wall.

(2) The duct shall be protected between the wall and the damper according to the fire resistance of the separating wall structure.

8.4.8.6 Fire dampers shall be designed and installed so that the air velocity in the ducts assists in closing fire dampers and does not preclude proper damper closure.

8.4.8.7 Ventilation ducts containing fire dampers shall be provided with access ports for ease of inspection and for replacement of the thermal element.

8.4.9 Filters.

8.4.9.1 Air entry filters shall have approved noncombustible filter media that produce a minimum amount of smoke (UL Class 1) when subjected to heat.

8.4.9.2 To decrease the fire hazard of air entry and oil-bath-type filters, only approved fire-resistive adhesives and oils meeting all of the following criteria shall be used:

(1) They shall be in accordance with ASTM D92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup.*
(2) Their flash points shall be equal to or greater than 464°F (240°C).
(3) They shall not produce appreciable smoke.

8.4.9.3 High-efficiency particulate air (HEPA) filters shall meet the requirements of UL 586, *Standard for Test Performance of High-Efficiency Particulate Air Filter Units.*

8.4.9.4 Fixed water spray systems shall be provided for charcoal adsorber beds containing more than 100 lb (45.4 kg) of charcoal.

8.4.9.5 Fire suppression systems shall be installed to protect filters that collect combustible material.

8.5 Drainage.

8.5.1* Drainage shall be provided in all areas of the plant for the removal of all liquids directly to safe areas or for containment in the area without adverse flooding of equipment and without endangering other areas.

8.5.2 Drainage and the prevention of equipment water damage shall 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

8.5.3 Drainage and any associated drainage facilities for a given area shall be sized to accommodate the volume of liquid produced by all of the following:

(1) The spill of the largest single container of any flammable or combustible liquids in the area
(2) Where automatic suppression is provided throughout, the credible volume of discharge (as determined by the fire hazards analysis) for the suppression system operating for a period of 30 minutes
(3)* Where automatic suppression is not provided throughout, the contents of piping systems and containers that are subject to failure in a fire
(4) Where the installation is outside, the volume of credible environmental factors such as rain and snow

(5) Where automatic suppression is not provided throughout, the volume based on a manual fire-fighting flow rate of 500 gpm (1892.5 L/min) for a duration of 30 minutes, unless the fire hazards analysis demonstrates a different flow rate and duration

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

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

8.5.6 Drainage facilities shall be provided for outdoor oil-insulated transformers, or the ground shall be sloped such that oil spills flow away from buildings, structures, and adjacent transformers.

8.5.6.1 Unless drainage from oil spills is accommodated by sloping the ground around transformers away from structures or adjacent equipment, consideration shall be given to providing curbed areas or pits around transformers.

8.5.6.2 If a layer of uniformly graded stone is provided in the bottom of the curbed area or pit as a means of minimizing ground fires, the following shall be assessed:

(1) The sizing of the pit shall allow for the volume of the stone.
(2) The design shall address the possible accumulation of sediment or fines in the stone.

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

8.5.8 Water drainage from areas that might contain radioactivity shall be collected, sampled, and analyzed before discharge to the environment.

8.5.9 Water released during fire suppression operations in areas containing radioactivity shall be drained to a location that is acceptable for the containment of radioactive materials.

8.6 Emergency Lighting.

8.6.1 Emergency lighting units shall provide lighting levels as required in 8.6.2.

8.6.2 The lighting units shall be sized to provide a duration of operation that will illuminate the egress and access routes to areas containing safe shutdown equipment and the equipment operation until all required operator actions are completed or until normal or emergency plant lighting can be reestablished.

8.6.3 The illumination of means of egress shall be in accordance with NFPA *101* and shall include emergency lighting and marking of the means of egress.

8.6.4 The floor of the means of egress and the safe shutdown operations shall be illuminated to values of not less than 1 footcandle measured at the floor and at safe shutdown equipment at all points, including the following:

(1) Angles
(2) Intersections of corridors
(3) Passageways
(4) Stairways
(5) Landings of stairways
(6) Exit doors
(7) Safe shutdown equipment
(8) Access and egress routes to safe shutdown equipment

8.6.5 The required illumination shall be so arranged that the failure of any single lighting unit, such as the burning out of a single light bulb, will not leave any area in darkness.

8.6.6 Suitable battery-powered hand lights shall be provided for emergency use by the fire brigade and other operations personnel required to achieve safe plant shutdown.

8.7 Lightning Protection. The plant shall be provided with a lightning protection system in accordance with NFPA 780.

8.8 Electrical Cabling.

8.8.1 As a minimum, combustible cable insulation and jacketing material shall meet the fire and flame test requirements of IEEE 1202, *Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies.*

8.8.2 Meeting the requirements of IEEE 383, *Standard for Type Test of Class IE Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations,* shall not eliminate the need for protection as specified in this standard and the fire hazards analysis.

8.8.3 Fiber optic cable insulation and jacketing material shall meet the fire and flame test requirements of IEEE 383, *Standard for Type Test of Class IE Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations.*

8.8.4 Group cabling shall be routed away from exposure hazards or protected as specified in this standard.

8.8.4.1 Group cabling shall not be routed near sources of ignition.

8.8.4.2 Group cabling shall not be routed near flammable and combustible liquid hazards.

8.8.5 Cable raceways shall be used only for cables.

8.8.6 Only metal shall be used for cable trays.

8.8.7 Only metallic tubing shall be used for conduit, unless otherwise permitted by 8.8.7.1.

8.8.7.1 Nonmetallic conduit shall be permitted to be used with concrete encasement or for direct burial runs.

8.8.7.2 Thin-wall metallic tubing shall not be used.

8.8.7.3 Flexible metallic tubing shall be used only in lengths less than 5 ft (1.5 m) to connect components to equipment.

8.8.7.4 Other raceways shall be made of noncombustible materials.

8.9* Exposure Protection. Buildings shall be protected from exposure fires by any one of the following:

(1) Listed 3-hour fire barrier with automatic or self-closing fire doors having a fire protection rating of 3 hours and a listed penetration protection rating of 3 hours
(2) Spatial separation of at least 50 ft (15.2 m)
(3) Exterior exposure protection

8.10 Electrical Systems for the Plant. The electrical design and installation of electrical generating, control, transmission, distribution, and metering of electrical energy shall be provided in accordance with *NFPA 70* or ANSI/IEEE C2, *National Electrical Safety Code*, as applicable.

8.11 Communications.

8.11.1 The plant-approved voice/alarm communications system in accordance with *NFPA 72* shall be available on a priority basis for fire announcements, directing the plant fire brigade, and fire evacuation announcements.

8.11.2* A portable radio communications system shall be provided for use by the fire brigade and other operations personnel required to achieve safe shutdown.

8.11.3 The radio communications system shall not interfere with the communications capabilities of the plant security force.

8.11.4 The impact of fire damage on the communications systems shall be considered when fixed repeaters are installed to permit the use of portable radios.

8.11.5 Repeaters shall be located such that a fire-induced failure of the repeater will not also cause failure of the other communications systems relied on for safe shutdown.

8.11.6* Plant control equipment shall be designed so that the control equipment is not susceptible to radio frequency interferences from portable radios.

8.11.7 Preoperational tests and periodic testing shall demonstrate that the frequencies used for portable radio communications will not affect actuation of protective relays or other electrical components.

Chapter 9 General Fire Protection Systems and Equipment

9.1 General.

9.1.1* A fire hazards analysis shall be conducted to determine the fire protection requirements for the facility.

9.1.2* All fire protection systems, equipment, and installations shall be dedicated to fire protection purposes unless permitted by the following:

(1) The requirement of 9.1.2 shall not apply to fire protection systems, equipment, and installations where in accordance with 9.4.10.
(2) Fire protection systems shall be permitted to be used to provide redundant backup to nuclear safety–related systems provided that both the following criteria are met:
    (a) The fire protection systems shall meet the design basis requirements of the nuclear safety–related systems.
    (b) Fire protection systems used in 9.1.2(2)(a) shall be designed to handle both functions.

9.1.3 All fire protection equipment shall be listed or approved for its intended service.

9.2 Water Supply.

9.2.1* The fire water supply shall be calculated on the basis of the largest expected flow rate for a period of 2 hours but shall not be less than 300,000 gal (1,135,500 L), and the following criteria also shall apply:

(1) The flow rate shall be based on 500 gpm (1892.5 L/min) for manual hose streams plus the largest design demand of any sprinkler or fixed water spray system as determined in accordance with this standard, with NFPA 13 or with NFPA 15.
(2) The fire water supply shall be capable of delivering the design demand specified in 9.2.1(1) with the hydraulically least demanding portion of the fire main loop out of service.

9.2.2* Two 100 percent [minimum of 300,000 gal (1,135,500 L) each] system capacity tanks shall be installed, and the following shall apply:

(1) The tanks shall be interconnected such that fire pumps can take suction from either or both.
(2) A failure in one tank or its piping shall not cause both tanks to drain.
(3) The tanks shall be designed in accordance with NFPA 22.
(4) Refill times for filling the water tanks shall not apply.

9.2.3* The tanks shall not be supplied by an untreated, raw water source.

9.2.4 Fire Pumps.

9.2.4.1 Fire pumps shall meet the requirements of NFPA 20 and shall be automatic starting.

9.2.4.2* Fire pumps shall be provided to ensure that 100 percent of the flow rate capacity will be available assuming failure of the largest pump.

9.2.4.3 Individual fire pump connections to the yard fire main loop shall be separated with sectionalizing valves between connections, and the following criteria also shall be met:

(1) Each pump and its driver and controls shall be located in a room separated from the remaining fire pumps by a fire wall with a minimum rating of 3 hours.
(2) The fuel for the diesel fire pump(s) shall be separated so that it does not provide a fire source exposing nuclear safety–related equipment.

9.2.4.4 A method of automatic pressure maintenance of the fire protection system shall be provided independent of the fire pumps.

9.2.4.5 Supervisory signals and visible indicators required by NFPA 20 shall be received in the control room.

9.3* Valve Supervision. All fire protection water supply and system control valves shall be under a periodic inspection program and shall 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 and monthly valve inspections
(2) Locking valves in their normal position and monthly valve inspections with keys made available only to authorized personnel
(3) Sealing valves in their normal positions and weekly valve inspections with this option utilized only where valves are located within fenced areas or under the direct control of the property owner

9.4 Yard Mains, Hydrants, and Building Standpipes.

9.4.1* The underground yard fire main loop shall be installed to furnish anticipated water requirements, and the following criteria also shall be met:

(1) The type of pipe and water treatment shall be design considerations, with tuberculation as one of the parameters.
(2) Means for inspecting and flushing the systems shall be provided.

9.4.2 Approved visually indicating sectional control valves such as postindicator valves shall be provided to isolate portions of the main for maintenance or repair without simultaneously shutting off the supply to both primary and backup fire suppression systems.

9.4.3 Valves shall be installed to allow isolation of outside hydrants from the fire main for maintenance or repair without interrupting the water supply to automatic or manual fire suppression systems.

9.4.4* Sectional control valves shall allow maintaining independence of the individual loop around each unit, and the following also shall apply:

(1) For such installations, common water supplies shall also be permitted to be utilized.
(2) For multiple-reactor sites with widely separated plants [approaching 1 mi (1.6 km) or more], separate yard fire main loops shall be used.

9.4.5 Outside manual hose installation shall provide an effective hose stream to any on-site location, and the following also shall apply:

(1) Hydrants with individual hose gate valves shall be installed approximately every 250 ft (76 m) apart on the yard main system.
(2) A hose house equipped with hose and combination nozzle and other auxiliary equipment specified in NFPA 24 shall be provided at intervals of not more than 1000 ft (305 m) along the yard main system.
(3) Mobile means of providing hose and associated equipment, such as hose carts or trucks, shall be permitted in lieu of hose houses, and where provided, such mobile equipment shall be equivalent to that supplied by three hose houses.

9.4.6 One of the following criteria shall be met:

(1) Threads compatible with those used by local fire departments shall be provided on all hydrants, hose couplings, and standpipe risers.
(2) The fire departments shall be provided with adapters that allow interconnection between plant equipment and the fire department equipment.

9.4.7 Sprinkler systems and manual hose station standpipes shall have connections to the plant underground water main so that a single active failure or a crack in a moderate-energy line can be isolated so as not to impair both the primary and the backup fire suppression systems unless otherwise permitted by the following:

(1) Alternatively, headers fed from each end shall be permitted inside buildings to supply both sprinkler and standpipe systems, provided steel piping and fittings meeting the requirements of ASME B31.1, *Power Piping*, are used for the headers (up to and including the first valve) supplying the sprinkler systems where such headers are part of the seismically analyzed hose standpipe system.
(2) Where provided, such headers shall be considered an extension of the yard main system.
(3) Each sprinkler and standpipe system shall be equipped with an outside screw and yoke (OS&Y) gate valve or other approved shutoff valve.

9.4.8 For all power block buildings, Class III standpipe and hose systems shall be installed in accordance with NFPA 14.

9.4.9 For all other buildings on site, the requirements for standpipe and hose systems shall be appropriate for the hazard being protected.

9.4.10* The proper type of hose nozzle to be supplied to each area shall be based on the fire hazards analysis, and the following criteria also shall apply:

(1) The usual combination spray/straight-stream nozzle shall not be used in areas where the straight stream can cause unacceptable damage.
(2) Approved, electrically safe fixed fog nozzles shall be provided at locations where high-voltage shock hazards exist.
(3) All hose nozzles shall have shutoff capability.

9.4.11 Seismic Fire Suppression Capabilities.

9.4.11.1* Provisions shall be made to supply water at least to standpipes and hose stations for manual fire suppression in all areas containing nuclear safety–related systems and components for safe shutdown in the event of a safe shutdown earthquake (SSE).

9.4.11.2 The piping system serving these hose stations shall be analyzed for safe shutdown and earthquake loading and shall be provided with supports that ensure pressure boundary integrity.

9.4.11.3 The piping and valves for the portion of hose standpipe system affected by the functional requirement of 9.4.11.2 shall, as a minimum, satisfy the requirements of ASME B31.1, *Power Piping*.

9.4.11.4 The system shall be designed to flow a minimum of one Class III standpipe station in accordance with NFPA 14.

9.4.11.5 Where the seismic required hose stations are cross-connected to essential seismic Category I water systems, the fire flow shall not degrade the essential water system requirements.

9.5 Portable Fire Extinguishers.

9.5.1 Portable and wheeled fire extinguishers shall be installed, inspected, maintained, and tested in accordance with NFPA 10 unless otherwise permitted by 9.5.2.

9.5.2 Where placement of extinguishers would result in required activities that are contrary to personnel radiological exposure concerns or nuclear safety–related concerns, fire extinguishers shall be permitted to be inspected at intervals greater than those specified in NFPA 10 or consideration shall be given to locating the extinguishers outside high-radiation areas.

9.6 Fire Suppression Systems.

9.6.1 Fire suppression systems shall be provided in all areas of the plant as required by the fire hazards analysis.

9.6.2 Except as modified in this chapter, the following NFPA standards shall be used:

(1) NFPA 11
(2) NFPA 12
(3) NFPA 13
(4) NFPA 14
(5) NFPA 15
(6) NFPA 16
(7) NFPA 17
(8) NFPA 750
(9) NFPA 2001
(10) NFPA 2010

9.6.3 The extinguishing systems chosen shall be based on the design parameters required as a result of the fire hazards analysis.

9.6.4 Selection of extinguishing agent shall be based on all of the following:

(1) Type or class of hazard
(2) Effect of agent discharge on critical equipment including:
    (a) Thermal shock
    (b) Continued operability
    (c) Water damage
    (d) Overpressurization
    (e) Cleanup
(3) Health hazards
(4) Effectiveness of agent in suppressing fire
(5) Cost of agent, including life-cycle costs
(6) Availability of agent
(7) Criticality safety
(8) Environmental impact

9.6.5 Each fire suppression system shall be equipped with approved alarming devices and shall annunciate in a constantly attended area.

9.7 Fire Alarm Systems.

9.7.1 Fire signaling systems shall be provided in all areas of the plant as required by the fire hazards analysis.

9.7.2 The requirements of this chapter shall constitute the minimum acceptable protective signaling system functions when used in conjunction with *NFPA 72*.

9.7.3* The signaling system's initiating device and signaling line circuits shall provide emergency operation for fire detection, fire alarm, and water flow alarm during a single break or a single ground fault.

9.7.4 The fire signaling equipment used for fixed fire suppression systems shall give audible and visual alarm and system trouble annunciation in the plant control room for the power block buildings, and the following shall apply:

(1) Local alarms shall be provided.
(2) Other fire alarm signals from other buildings shall be permitted to annunciate at the control room or other locations that are constantly attended.

9.7.5* Audible signaling appliances shall meet the following criteria:

(1) They shall produce a distinctive sound, used for no other purpose.
(2) They shall be located and installed so that the alarm can be heard above ambient noise levels.

9.7.6 Plant control room or plant security personnel shall be trained in the operation of all fire signaling systems used in the plant, including the ability to identify any alarm zone or fire protection system that is operating.

9.7.7 Fire signaling equipment and actuation equipment for the release of fixed fire suppression systems shall be connected to power supply sources in accordance with the requirements of *NFPA 72* and shall be routed outside the area to be protected.

9.7.8* Manual fire alarm boxes shall be installed as required by the fire hazards analysis, and the following criteria also shall be met:

(1) Where manual release devices are installed for the purpose of releasing an extinguishing agent in a fixed fire suppression system, the manual releases shall be marked for that purpose.
(2) The manual release device circuits shall be routed outside the area protected by the fixed extinguishing system.

9.7.9 All signals shall be permanently recorded in accordance with *NFPA 72*.

9.8 Fire Detectors. Automatic fire detectors shall be selected and installed in accordance with all of the following:

(1) *NFPA 72*
(2) Design parameters required as a result of the fire hazards analysis of the plant area
(3) Additional requirements of this standard

Chapter 10 Identification of and Protection Against Hazards

10.1* General.

10.1.1 The identification and selection of fire protection systems shall be based on the fire hazards analysis.

10.1.2 This chapter identifies fire and explosion hazards in advanced light water reactor plants and specifies the protection criteria that shall be used unless the fire hazards analysis indicates otherwise.

10.2 Primary and Secondary Containments.

10.2.1 Normal Operation. Fire protection for the primary and secondary containment areas shall be provided for hazards identified by the fire hazards analysis.

10.2.1.1 Operation of the fire protection systems shall not compromise the integrity of the containment or other safety-related systems.

10.2.1.2 Fire protection systems in the containment areas shall function in conjunction with total containment requirements such as ventilation and control of containment liquid and gaseous release.

10.2.1.3 Inside primary containment, fire detection systems shall be provided for each fire hazard identified in the fire hazards analysis.

10.2.1.4 The type of detection used and the location of the detectors shall be the most suitable for the particular type of fire hazard identified by the fire hazards analysis.

10.2.1.5 A general area fire detection capability shall be provided in the primary containment as a backup for the hazard

detection described in 10.2.1.4 by the installation of smoke or heat detectors compatible with the radiation environment in accordance with *NFPA 72*.

10.2.1.6 Standpipe and hose stations shall be installed inside containment. Standpipe and hose stations inside containment shall be permitted to be connected to a high-quality water supply of the required quantity and pressure other than the fire main loop if plant-specific features prevent extending the fire main supply inside containment.

10.2.1.7 For inerted primary containment, standpipe and hose stations shall be permitted to be placed outside the primary containment, with hose no longer than 100 ft (30.5 m), to reach any location inside the primary containment with a 30 ft (9.1 m) effective hose stream.

10.2.1.8 Reactor coolant pumps with an external lubrication system shall be provided with an oil collection system.

10.2.1.9 The oil collection system shall be so designed, engineered, and installed that failure of the oil collection system will not lead to a fire during normal operations or off-normal conditions such as accident conditions or earthquakes.

10.2.1.10* The oil collection systems shall be capable of collecting oil from all potential pressurized and unpressurized leakage sites in the reactor coolant pump oil systems, and the following criteria also shall apply:

(1) Leakage shall be collected and drained to a vented closed container that can hold the entire oil system inventory.
(2) Leakage points to be protected shall include the following, where such features exist on the reactor coolant pumps:
    (a) Lift pump and piping
    (b) Overflow lines
    (c) Oil cooler
    (d) Oil fill
    (e) Drain lines and plugs
    (f) Flanged connections on oil lines
    (g) Oil reservoirs
(3) The drain line shall be large enough to accommodate the largest potential oil leak.

10.2.2 Refueling and Maintenance.

10.2.2.1* Management procedures and controls necessary to ensure fire protection for fire hazards introduced during maintenance and refueling shall be provided.

10.2.2.2 Backup fire suppression shall be provided so that total reliance is not placed on a single fire suppression system.

10.2.2.3 Self-contained breathing apparatus meeting the following criteria shall be provided near the containment entrance for fire-fighting and damage control personnel:

(1) The units shall be independent of any breathing apparatus or air supply systems provided for general plant activities.
(2) The units shall be marked as emergency equipment.

10.3 Control Room Complex.

10.3.1 The control room complex (including kitchen, office spaces, etc.) shall be protected against disabling fire damage and shall be separated from other areas of the plant by floors, walls, ceilings, and roofs having a minimum fire resistance rating of 3 hours.

10.3.2 Peripheral rooms in the control room complex shall have an automatic water-based suppression system, where required by the fire hazards analysis, and shall be separated from the control room by noncombustible construction with a minimum fire resistance rating of 1 hour.

10.3.3 Ventilation system openings between the control room and the peripheral rooms shall have automatic smoke dampers installed that close on operation of the fire detection and fire suppression systems.

10.3.4 Manual fire-fighting capability shall be provided for both of the following:

(1) Fires originating within a cabinet, console, or connecting cables
(2) Exposure fires involving combustibles in the general room area

10.3.5 Portable Class A and Class C fire extinguishers shall be located in the control room, and a fire hose station shall be installed outside the control room.

10.3.6 Nozzles that are compatible with the hazards and the equipment in the control room shall be provided for the fire hose stations.

10.3.7 The choice of nozzles shall satisfy fire-fighting requirements and electrical safety requirements and shall minimize physical damage to electrical equipment from hose stream impingement.

10.3.8 Smoke detectors shall be provided in the control room complex, the electrical cabinets, and the consoles.

10.3.9 If redundant safe shutdown equipment is located in the same control room cabinet or console, the cabinet or console shall be provided with internal separation (noncombustible barriers) to limit the damage to one safety division.

10.3.10 Breathing apparatus for the control room operators shall be available.

10.3.11 The outside air intakes for the control room ventilation system shall be provided with smoke detection capability to alarm in the control room and enable manual isolation of the control room ventilation system, thus preventing smoke from entering the control room.

10.3.12 Venting of smoke produced by a fire in the control room by means of the normal ventilation system shall be permitted to be acceptable if provision is made for isolation of the recirculation portion of the normal ventilation system.

10.3.13 Manually operated venting of the control room shall be available to the operators.

10.3.14 All cables that enter the control room shall terminate in the control room, and the following criteria also shall apply:

(1) No cabling shall be routed through the control room from one area to another.
(2) Cables in spaces underfloor and in above-ceiling spaces shall meet the separation criteria necessary for fire protection.

10.3.15 Air-handling functions shall be ducted separately from cable runs in such spaces (underfloor and above ceiling, such spaces shall not be used as air plenums for ventilation of the control room).

10.3.16 Fully enclosed electrical raceways located in such underfloor and ceiling spaces, if over 1 ft^2 (0.09 m^2) in cross-sectional area, shall have automatic fire suppression inside.

10.3.17 Area automatic fire suppression shall be provided for underfloor and ceiling spaces if used for cable runs unless all cable is run in 4 in. (101.6 mm) or smaller steel conduit or cables are in fully enclosed raceways internally protected by automatic fire suppression.

10.4 Cable Concentrations.

10.4.1 Cable Spreading Room.

10.4.1.1 The cable spreading room shall have an automatic fixed water-based suppression system, and the following criteria also shall be met:

(1) The location of sprinklers or spray nozzles shall protect cable tray arrangements to ensure water coverage for areas that could present exposure fire hazards to the cable raceways.
(2) Automatic sprinkler systems shall be designed for a density of 0.30 gpm/ft^2 (12.2 L/min·m^2) over the most remote 2500 ft^2 (232.2 m^2).

10.4.1.2 Suppression systems shall be zoned to limit the area of protection to that which the drainage system can handle with any two adjacent systems actuated.

10.4.1.3 Deluge and water spray systems shall be hydraulically designed with each zone calculated with the largest adjacent zone flowing.

10.4.1.4 Cable spreading rooms shall be provided with all of the following:

(1) At least two remote and separate entrances for access by the fire brigade personnel
(2) Aisle separation between tray stacks at least 3 ft (0.9 m) wide and 8 ft (24 m) high
(3) Hose stations and portable fire extinguishers installed outside the room
(4)* Area smoke detection

10.4.2 Cable Tunnels.

10.4.2.1* Detection Systems. Cable tunnels shall be provided with smoke detection.

10.4.2.2 Suppression Systems.

10.4.2.2.1 Cable tunnels shall be provided with automatic fixed suppression systems.

10.4.2.2.2 Automatic sprinkler systems shall be designed for a density of 0.30 gpm/ft^2 (12.2 L/min·m^2) for the most remote 100 linear ft (30.5 m) of cable tunnel up to the most remote 2500 ft^2 (232.2 m^2).

10.4.2.2.3 The location of sprinklers or spray nozzles shall protect cable tray arrangements and possible transient combustibles to ensure water coverage for areas that could present exposure fire hazards to the cable raceways.

10.4.2.2.4 Deluge sprinkler systems or deluge spray systems shall meet the following criteria:

(1) They shall be zoned to limit the area of protection to that which the drainage system can handle with any two adjacent systems actuated.
(2) They shall be hydraulically designed with each zone calculated with the largest adjacent zone flowing.

10.4.2.3 Cables shall be designed to allow wetting of undamaged cables with water supplied by the fire suppression system without electrical faulting.

10.4.2.4 Cable tunnels over 50 ft (15.2 m) long shall be provided with all of the following:

(1) At least two remote and separate entrances for access by the fire brigade personnel
(2) An aisle separation between tray stacks at least 3 ft (0.9 m) wide and 8 ft (2.4 m) high
(3) Hose stations and portable fire extinguishers installed outside the tunnel

10.4.3 Cable Shafts and Risers. Cable tray fire breaks shall be installed every 20 ft (6.1 m) for vertical cable trays that rise over 30 ft (9.1 m), and the following criteria also shall be met:

(1) Access to cable shafts shall be provided every 40 ft (12.2 m) with the topmost access within 20 ft (6.1 m) of the cable shaft ceiling.
(2) Automatic sprinkler protection and smoke detection shall be provided at the ceiling of the vertical shaft.

10.5 Plant Computer and Communications Rooms. Computer and communications rooms shall meet the applicable requirements of NFPA 75.

10.6 Switchgear Rooms and Relay Rooms.

10.6.1* Smoke detection shall be provided and shall alarm in both the control room and locally, and the following criteria also shall apply:

(1) Cables entering the safety-related switchgear rooms shall terminate in the switchgear room.
(2) The safety-related switchgear rooms shall not be used for other purposes.
(3) Fire hose stations and portable fire extinguishers shall be readily available outside the area.

10.6.2* Equipment shall be located to facilitate fire fighting, and the following criteria also shall be met:

(1) Drains shall be provided to prevent water accumulation from damaging safety-related equipment.
(2) Remote manually actuated ventilation shall be provided for smoke removal when manual fire suppression is needed.

10.7 Battery Rooms.

10.7.1* Battery rooms shall be provided with ventilation to limit the concentration of hydrogen to 2 percent by volume, and loss of ventilation shall alarm in the control room.

10.7.2 Safety-related battery rooms shall be protected against fires and explosions, and the following criteria also shall apply:

(1) Battery rooms shall be separated from other areas of the plant by fire barriers having a 1-hour minimum rating.
(2) Direct current switchgear and inverters shall not be located in the battery rooms.
(3) Fire detection shall be provided.
(4) Fire hose stations and portable fire extinguishers shall be available outside the room.

10.8 Turbine Building.

10.8.1* The turbine building shall be separated from adjacent structures containing safety-related equipment by fire-resistive barriers having a minimum 3-hour rating, and the following criteria also shall apply:

(1) The fire barriers shall be designed so that the barrier will remain in place even in the event of complete collapse of the turbine structure.
(2) Openings and penetrations shall be minimized in the fire barrier and shall not be located where turbine oil systems or generator hydrogen cooling systems create a direct fire exposure hazard to the fire barrier.
(3) Smoke and heat removal systems shall be provided in accordance with 8.4.3.
(4) For those plants provided with complete automatic sprinkler protection at the roof level, smoke and heat removal systems shall not be required.

10.8.2 Beneath Turbine Generator Operating Floor.

10.8.2.1* All areas beneath the turbine generator operating floor shall be protected by an automatic sprinkler or foam-water sprinkler system meeting the following criteria:

(1) The sprinkler system beneath the turbine generator shall be designed around obstructions from structural members and piping.
(2) The sprinkler system shall be designed to a minimum density of 0.30 gpm/ft^2 (12.2 L/min·m^2) over a minimum application of 5000 ft^2 (464.5 m^2).

10.8.2.2 Foam-water sprinkler systems installed in place of automatic sprinklers described in 10.8.2.1 shall be designed in accordance with NFPA 16 and the design densities specified in 10.8.2.1.

10.8.2.3 Electrical equipment in the area covered by a water or foam system shall be of the enclosed type or otherwise protected to minimize water damage in the event of system operation.

10.8.3* Turbine Generator Bearings.

10.8.3.1 Automatic fixed suppression systems shall be provided for all turbine generator and exciter bearings.

10.8.3.2 If closed-head water spray systems utilizing directional nozzles in accordance with NFPA 15 are provided, bearing protection shall be provided for a minimum density of 0.30 gpm/ft^2 (12.2 L/min·m^2) over the protected area.

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

10.8.4 Lubricating oil lines above the turbine operating floor shall be protected with an automatic sprinkler system to a minimum density of 0.30 gpm/ft^2 (12.2 L/min·m^2) that covers those areas subject to oil accumulation, including the area within the turbine lagging (skirt).

10.8.5 Lubricating oil reservoirs and handling equipment shall be protected in accordance with 10.8.2.1.

10.8.6 If the lubricating oil reservoir specified in 10.8.5 is elevated, sprinkler protection shall be extended to protect the area beneath the reservoir.

10.8.7 The following shall apply to protection associated with shaft-driven ventilation systems:

(1) Where shaft-driven ventilation systems are not used, the area inside a directly connected exciter housing shall be protected with an automatic fire suppression system.
(2) Where shaft-driven ventilation systems are used, an automatic preaction sprinkler system providing a density of 0.30 gpm/ft^2 (12.2 L/min·m^2) over the entire area shall be provided.

10.8.8* Clean- or dirty-oil storage areas shall be protected based on the fire risk evaluation, and the designer shall include, as a minimum, the installation of fixed automatic fire protection systems and the ventilation and drainage requirements in Chapter 8.

10.8.9 Hydrogen Systems.

10.8.9.1* General.

10.8.9.1.1* Bulk hydrogen systems supplying one or more generators shall have automatic valves located at the supply and operable by "dead man"–type controls at the generator fill point(s) or operable from the control room.

10.8.9.1.2 As an alternative to the requirement of 10.8.9.1.1, vented guard piping shall be permitted to be used inside the building to protect runs of hydrogen piping.

10.8.9.1.3 A flanged spool piece or equivalent arrangement shall be provided to facilitate the separation of hydrogen supply when the generator is open for maintenance.

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

10.8.9.1.5 The generator hydrogen dump valve and hydrogen-detraining equipment shall meet the following criteria:

(1) They shall be arranged to vent directly to a safe outside location.
(2) The dump valve shall be remotely operable from the control room or from an area accessible during a machine fire.

10.8.9.1.6* An excess-flow check valve shall be provided for the bulk supply hydrogen piping.

10.8.9.2 Hydrogen Seal Oil Pumps.

10.8.9.2.1 Redundant hydrogen seal oil pumps with separate power supplies shall be provided for reliability of seal oil supply.

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

10.8.9.2.3 Hydrogen seal oil units shall be protected as follows:

(1) In accordance with 10.8.2
(2) By an automatic, open-head water spray system providing a density of 0.30 gpm/ft^2 (12.2 L/min·m^2) over the hydrogen seal area

10.8.9.2.4 Curbing or drainage or both shall be provided for the hydrogen seal oil unit in accordance with Section 8.5.

10.8.9.3 Hydrogen in Safety-Related Areas.

10.8.9.3.1 Hydrogen lines in safety-related areas shall meet one of the following criteria:

(1) They shall be designed to seismic Class I requirements or sleeved such that the outer pipe is directly vented to the outside.
(2) They shall be equipped with excess-flow valves so that, in case of a line break, the hydrogen concentration in the affected areas will not exceed 2 percent.

10.8.9.3.2 Hydrogen lines or sensing lines containing hydrogen shall not be piped into or through the control room.

10.8.10 Hydraulic Control Systems. The hydraulic control system shall use a listed fire-resistant fluid.

10.8.11* Lubricating Oil Systems.

10.8.11.1 Turbine lubricating oil reservoirs shall be provided with vapor extractors, which shall be vented to an outside location.

10.8.11.2 Curbing or drainage or both shall be provided for the turbine lubricating oil reservoir in accordance with Section 8.5.

10.8.11.3 All oil pipe serving the turbine generator shall be designed and installed to minimize the possibility of an oil fire in the event of severe turbine vibration.

10.8.11.4 Piping design and installation shall include all of the following measures:

(1) Welded construction
(2)* Guard pipe construction with the pressure feed line located inside the return line or in a separate shield pipe drained to the oil reservoir
(3) Routing oil piping clear of or below steam piping or metal parts
(4) Insulating with impervious lagging for steam piping or hot metal parts under or near oil piping or turbine bearing points

10.8.11.5 Cable for operation of the lubricating oil pumps shall be protected from fire exposure, and the following criteria also shall apply:

(1) Where feasible, electrical circuits to redundant pumps shall be run in buried conduit.
(2) Protection shall be permitted to consist of separation of cables for ac and dc oil pumps or 1-hour fire-resistive coating (derating of cable shall be considered).

10.9 Standby Emergency Diesel Generators and Combustion Turbines.

10.9.1 The installation and operation of standby emergency diesel generators and combustion turbines shall be in accordance with NFPA 37 unless otherwise permitted by 10.9.2.

10.9.2 The requirement of 10.9.1 shall not apply to automatic shutdown and remote shutdown features, which shall be governed by nuclear-safety requirements.

10.9.3 Standby emergency diesel generators and combustion turbines located within main plant structures shall be protected as follows:

(1) They shall be protected by automatic sprinkler, water spray, or foam-water sprinkler systems.
(2) The sprinkler and water spray protection systems shall be designed for a 0.25 gpm/ft^2 (10.19 L/min·m^2) density over the entire area.

10.9.4 Fire detection shall be provided to alarm and annunciate in the control room and to alarm locally, and the following criteria also shall be met:

(1) Fire hose stations and portable fire extinguishers shall be located outside the area.
(2) Drainage for fire-fighting water and means for local manual venting of smoke shall be provided.

10.9.5 A day tank shall be permitted in standby emergency diesel generator and combustion turbine rooms if the day tank is located in a diked enclosure that has sufficient capacity to hold 110 percent of the contents of the day tank or is drained to a safe location.

10.10 Diesel Fuel Storage and Transfer Areas.

10.10.1* Diesel fuel oil storage tanks shall not be located inside buildings containing other nuclear safety–related equipment, and the following criteria also shall apply:

(1) If aboveground tanks are used, they shall be located at least 50 ft (15.2 m) from any building, or if within 50 ft (15.2 m), they shall be separated from the building by a fire barrier having a minimum 3-hour rating.
(2) Potential oil spills shall be confined or directed away from buildings containing safety-related equipment.

10.10.2 Aboveground tanks shall be provided with automatic fire suppression systems.

10.11 Nuclear Safety–Related Pump Rooms. Nuclear safety–related pump rooms shall be protected by fire detection systems, and the following criteria also shall apply:

(1) Automatic fire suppression systems shall be provided unless the fire hazards analysis determines that fire suppression is not required.
(2) Fire hose stations and fire extinguishers shall be readily accessible.

10.12 New-Fuel Area.

10.12.1 Fire extinguishers shall be located within the new-fuel area, and the following criteria also shall be met:

(1) Fire hose stations shall be located as determined by the fire hazards analysis to facilitate access and use for fire-fighting operations.
(2) Fire detection systems shall be provided.
(3) Combustible material shall be limited to the minimum necessary for operation in the new-fuel area.

10.12.2 The storage configuration of new fuel shall always be maintained as to preclude criticality for any water density that could occur during fire water application.

10.13 Spent-Fuel Pool Area.

10.13.1 Protection for the spent-fuel pool area shall be provided by fire hose stations and fire extinguishers.

10.13.2 Fire detection shall be provided in the area.

10.14 Rad Waste and Decontamination Areas.

10.14.1 Fire barriers, fire detection, and automatic fire suppression shall be provided as determined by the fire hazards analysis.

10.14.2 Manual ventilation control to assist in smoke removal shall be provided if necessary for manual fire fighting.

10.15 Safety-Related Water Tanks.

10.15.1 Storage tanks that supply water for fire-safe shutdown shall be protected from the effects of an exposure fire.

10.15.2 Combustible materials shall not be stored next to these tanks.

10.16 Record Storage Areas.

10.16.1 Record storage areas shall be located and protected in accordance with NFPA 232.

10.16.2 Record storage areas shall not be located in safety-related areas and shall be separated from safety-related areas by fire barriers having a minimum 3-hour rating.

10.17 Cooling Towers.

10.17.1 Cooling towers shall be of noncombustible or limited-combustible construction.

10.17.2 Cooling towers shall be located such that a fire in the cooling tower will not adversely affect safety-related systems or equipment.

10.17.3 The following criteria also shall be met:

(1) Cooling towers shall be of noncombustible construction when the basin is used as the ultimate heat sink.
(2) If cooling towers are of combustible construction, the following criteria shall be met:
    (a) They shall be protected by automatic sprinklers or water spray systems in accordance with NFPA 214.
    (b) They shall be located so that they do not affect safety-related systems or equipment in the event of a fire.

10.18 Acetylene–Oxygen Fuel Gases. Gas cylinder storage locations or the fire protection systems that serve those safety-related areas shall not be in areas that contain or expose safety-related equipment.

10.19 Storage Areas for Ion Exchange Resins. Unused ion exchange resins shall not be stored in areas that contain or expose safety-related systems or equipment.

10.20 Storage Areas for Hazardous Chemicals. Hazardous chemicals shall not be stored in areas that contain or expose safety-related systems or equipment.

10.21 Warehouses. Automatic sprinkler protection shall be provided for warehouses that contain high-value equipment or combustible materials.

10.22 Fire Pump Room/House.

10.22.1 Rooms housing diesel-driven fire pumps shall be protected by automatic sprinkler, water spray, or foam-water sprinkler systems.

10.22.2 If sprinkler and water spray systems are provided for fire pump houses, they shall be designed for a minimum density of 0.25 gpm/ft^2 (10.19 L/min·m^2) over the entire fire area.

10.23 Transformers.

10.23.1 Buildings shall be protected from exposure fires involving oil-filled transformers by one of the following means:

(1) Locating the transformer casing, conservator tank, and cooling radiators at least 50 ft (15.2 m) from buildings
(2) Providing a minimum 2-hour fire barrier between transformers as required in Figure 10.23.1(a) and Figure 10.23.1(b) and exposed buildings
(3) Complying with Table 10.23.1 *[See Figure 10.23.1(a) and Figure 10.23.1(b).]*

10.23.1.1 A minimum 1-hour fire barrier or a distance of 30 ft (9.1 m) shall be provided between adjacent transformers.

10.23.1.2 Means shall be provided to contain oil spills.

10.23.1.3 Adjacent oil-insulated transformers containing 500 gal (1890 L) or more of oil shall be separated from each other by a 2-hour-rated firewall or by spatial separation in accordance with Table 10.23.1.

10.23.1.4 Where a firewall as described in 10.23.1.3 is provided between transformers, it shall 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 oil containment, whichever is greater.

10.23.2 Oil-filled main, station service, and startup transformers shall be protected with automatic water spray systems in accordance with NFPA 15 or foam-water spray systems in accordance with NFPA 16.

10.23.3 Transformers installed inside fire areas containing safety-related systems or equipment shall be of the dry type or insulated and cooled with noncombustible liquid, unless otherwise specified in 10.23.4.

10.23.4* Transformers filled with combustible fluid that are located indoors shall be enclosed in a transformer vault.

10.24 Auxiliary Boilers.

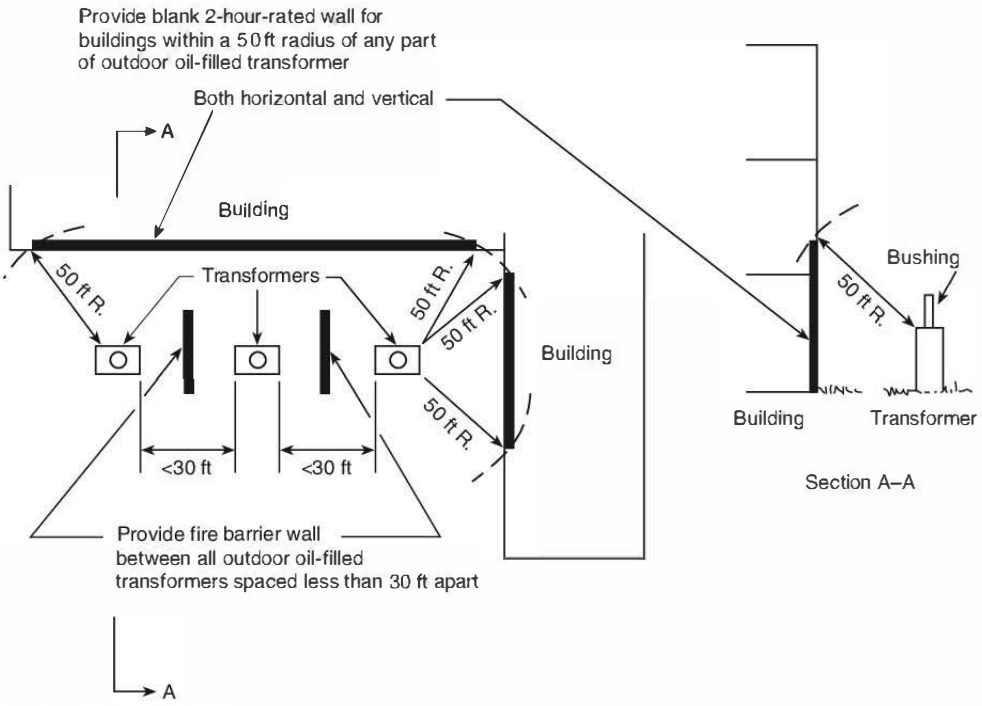
10.24.1 Auxiliary boilers, their fuel-burning systems, combustion product removal systems, and related control equipment shall be installed and operated in accordance with NFPA 85.

10.24.2 Oil-fired boilers or boilers using oil ignition within the main plant shall be protected with automatic sprinkler, water spray, or foam-water sprinkler systems covering the boiler area.

10.24.3 Sprinkler and water spray systems shall be designed for a minimum density of 0.25 gpm/ft^2 (10.19 L/min·m^2) over the entire area.

Table 10.23.1 Transformer Spacing Separation Distances

Transformer Oil Capacity		Minimum (Line-of-Sight) Separation Without Firewall	
gal	L	ft	m
≤5000	≤18.925	25	7.6
>5000	>18.925	50	15.2



For SI units: 1 ft = 0.3048 m.

FIGURE 10.23.1(a) Transformer Spacing.

10.25 Offices, Shops, and Storage Areas. Automatic sprinklers shall be provided for storage rooms, offices, and shops containing combustible materials that present an exposure to surrounding areas that are critical to plant operation and shall be so located and protected that a fire or the effects of a fire, including smoke, will not adversely affect any safety-related systems or equipment.

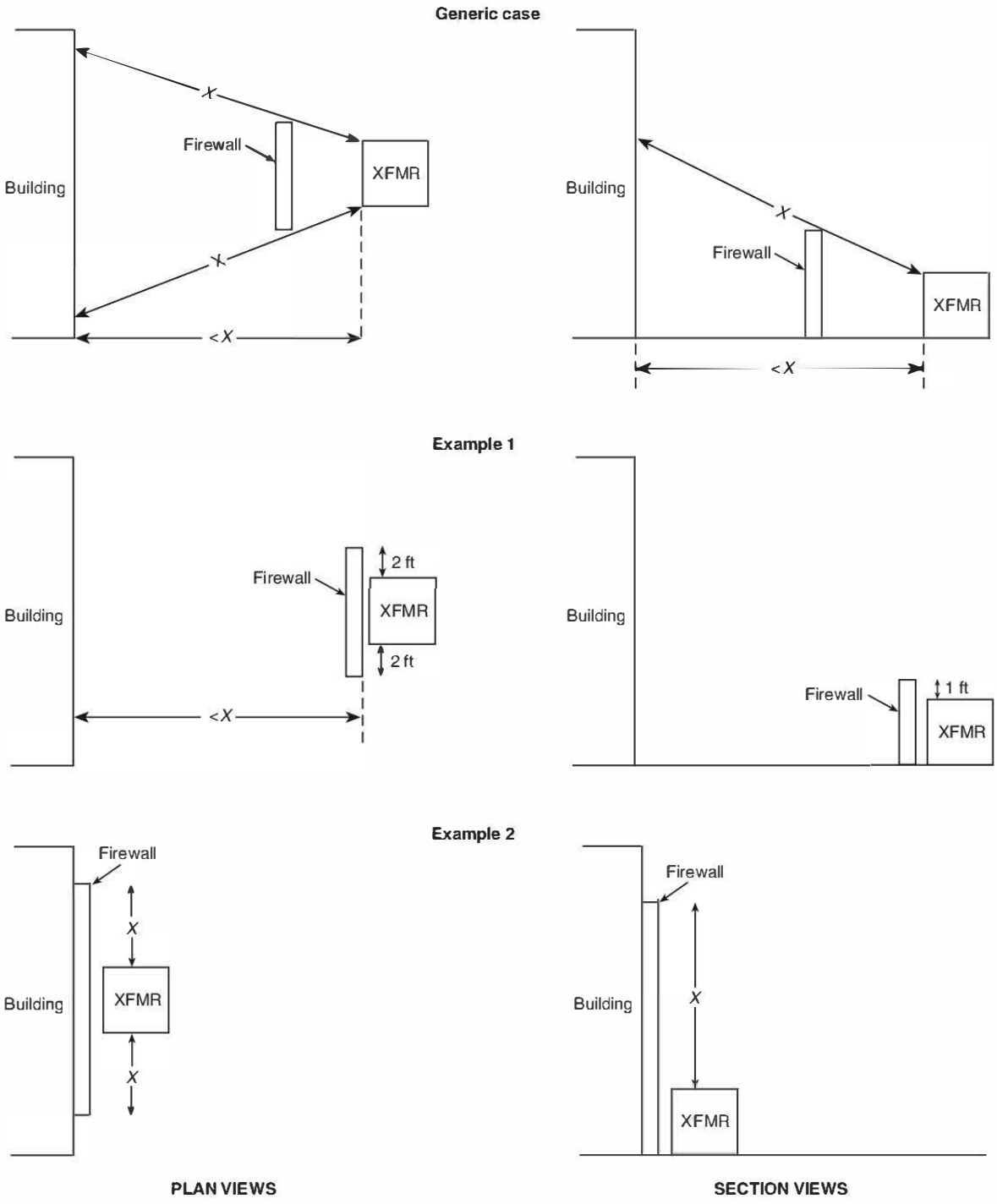
10.26 Simulators.

10.26.1 Simulators shall be provided with a fixed automatic suppression system.

10.26.2 Simulators and supporting equipment shall be separated from other areas by a fire barrier with a minimum 1-hour rating.

10.27 Technical Support and Emergency Response Centers. Technical support centers shall be separated from all other areas by fire barriers or from all other buildings by at least 50 ft (15.2 m) and be protected by an automatic fixed suppression system as required by the fire hazards analysis.

10.28 Intake Structures. Intake structures shall be of noncombustible construction and shall be provided with automatic sprinkler protection.



Notes:
(1) *X*= Minimum separation distance, from Table 10.23.1.
(2) For SI units: 1 ft = 0.3048 m.

FIGURE 10.23.1(b) Transformer Spacing — Minimum Separation Distance.

Chapter 11 Fire Protection for the Construction Site

11.1* General. Consideration of fire protection shall include safety to life and potential for delays in construction schedules and plant startup, as well as protection of property.

11.2 Administration.

11.2.1 The responsibility for fire protection for the entire site during the construction period shall be defined.

11.2.2 The administrative responsibilities shall be to develop, implement, and periodically update as necessary the measures outlined in this standard.

11.2.3 The responsibility for fire protection programs among various organizations on-site shall be delineated.

11.2.4 The fire protection program to be followed and the owner's right to administration and enforcement shall be established.

11.2.5 The fire protection program shall include a fire risk evaluation of the construction site and construction activities.

11.2.6 Written procedures in accordance with Chapter 5 shall be established for the new construction site, including major construction projects in existing plants.

11.2.7* Security guard service, including recorded rounds, shall be provided through all areas of construction during times when construction activity is not in progress.

11.2.8 Construction schedules shall be coordinated so that the planned permanent fire protection systems are installed and placed in service.

11.2.9 Construction and installation of fire barriers and fire doors shall be given priority in the construction schedule.

11.3 Site Clearing and Construction Equipment.

11.3.1 Site Clearing.

11.3.1.1 Prior to clearing forest and brush-covered areas, the following actions shall be taken:

(1) The owner shall ensure that a written fire control plan is prepared and that fire-fighting tools and equipment are made available as required by NFPA 1143.
(2) Contact shall be made with local fire and forest agencies for current data on restrictions and fire potential and to arrange for necessary permits.

11.3.1.2 The following shall apply to all construction vehicles and engine-driven portable equipment:

(1) They shall be equipped with effective spark arresters.
(2) Vehicles equipped with catalytic converters shall be prohibited from wooded and heavily vegetated areas.

11.3.1.3 Fire tools and equipment shall be distinctly marked and used for fire emergencies only.

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

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

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

11.4 Construction Warehouses, Shops, and Offices.

11.4.1 All structures that are to be retained as part of the completed plant shall be constructed of materials as indicated in Chapter 10 and in accordance with other applicable sections in this standard.

11.4.2* Construction warehouses, offices, trailers, sheds, and other facilities for the storage of tools and materials shall be located with consideration of their exposure to major plant buildings or other important structures.

11.4.3* A fire risk evaluation shall be performed.

11.4.4 Warehouses that contain high-value equipment (as defined by the individual responsible for fire prevention and fire protection) or contents the loss of which or damage to would cause a delay in startup dates of the completed plant shall meet the following criteria:

(1) They shall be arranged and protected as indicated in 11.4.4.1 through 11.4.4.4.
(2) Although some of these structures are considered to be temporary and will be removed on completion of the plant, the fire and loss potential shall be evaluated and protection provided where warranted.

11.4.4.1 Building construction materials shall be noncombustible or limited-combustible.

11.4.4.2 Automatic sprinkler systems shall be designed and installed in accordance with NFPA 13.

11.4.4.3 Waterflow alarms shall be provided and located so as to be monitored at a constantly attended location as determined by the individual responsible for fire protection.

11.4.4.4* Air-supported structures shall be used only for the storage of noncombustibles.

11.4.5 Temporary enclosures, including trailers, inside permanent plant buildings shall be prohibited except where permitted by the individual responsible for fire prevention and fire protection.

11.4.6 Where the floor area of a combustible enclosure exceeds 100 ft^2 (9.29 m^2) or where the occupancy presents a fire exposure, the enclosure shall be protected with an approved automatic fire suppression system.

11.4.7 Storage of construction materials, equipment, or supplies that are either combustible or in combustible packaging shall be prohibited in main plant buildings unless either of the following conditions exists:

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

11.4.8 Construction areas that comprise mobile buildings arranged with the buildings adjoining each other to form one large fire area shall be avoided.

11.4.9 If buildings cannot be separated, fire walls shall be installed between units or automatic sprinklers shall be provided throughout the buildings.

11.4.10 Fire alarms shall be connected to a constantly attended central location.

11.4.11 The handling, storage, and dispensing of flammable liquids and gases shall meet the requirements of NFPA 30 and NFPA 58.

11.4.12 Vehicle repair facilities shall meet the requirements of NFPA 30A.

11.5 Construction Site Lay-Down Areas.

11.5.1 Fire hydrant systems with an approved water supply shall be provided in lay-down areas where the need is determined by the individual responsible for fire prevention and fire protection.

11.5.2 Combustible materials shall be separated by a clear space to allow access for manual fire-fighting equipment.

11.5.3 Access shall be provided and maintained to all fire-fighting equipment, including fire hoses, extinguishers, and hydrants.

11.6 Temporary Construction Materials.

11.6.1* Noncombustible or fire-retardant scaffolds, formwork, decking, and partitions shall be used both inside and outside permanent buildings where a fire could cause substantial damage or delay construction schedules.

11.6.2* The use of listed pressure-impregnated fire-retardant lumber or listed fire-retardant coatings shall be provided.

11.6.3 Tarpaulins (fabrics) and plastic films shall be certified to conform to the weather-resistant and fire-retardant materials described in NFPA 701.

11.6.4 Where it is necessary to store new nuclear fuel in areas other than the permanent storage facilities, a written procedure shall be developed to address separation from the following:

(1) Combustible materials
(2) Security
(3) Nuclear criticality
(4) Packing material
(5) Noncombustible or limited-combustible building materials
(6) Standpipe
(7) Portable fire extinguishers
(8) Hydrant protection

11.7 Water Supplies, Supply Mains, and Hydrants.

11.7.1* General. The permanent underground yard system, fire hydrants, and water supply (at least one water source), as indicated in Chapter 10, shall be installed during the early stages of construction.

11.7.1.1 Where provision of all or part of the permanent underground system and water supply is not practical, temporary systems shall be provided.

11.7.1.2 Temporary water supplies shall be hydrostatically tested, flushed, and arranged to maintain a high degree of reliability, including protection from freezing and loss of power.

11.7.2 Hydrants shall be installed as specified in 11.7.2.1 and 11.7.2.2.

11.7.2.1 Hydrants shall be installed in the vicinity of main plant buildings, important warehouses, office or storage trailer complexes, and outside structures with combustible construction or combustible concrete formwork (e.g., cooling towers).

11.7.2.2 The underground main shall be arranged to minimize the possibility that any one break will remove from service any fixed water extinguishing system or leave any area without accessible hydrant protection.

11.7.3 A fire protection water supply shall be provided on the construction site and shall be capable of furnishing the larger of the following for a minimum 2-hour duration:

(1) 500 gpm (1892.5 L/min)
(2) The in-service fixed water extinguishing system with the highest water demand and 500 gpm (1892.5 L/min) for hose streams

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

11.7.3.2* As fixed water extinguishing systems are completed, they shall be placed in service, even when the available construction phase fire protection water supply is not able to meet the designed system demand, and the following criteria shall be met:

(1) When the permanent hazard is introduced, the water supply shall be capable of providing the designed system demand.
(2) Where construction water is used in permanent systems, adequate strainers shall be provided to prevent clogging of the system by foreign objects and dirt.

11.7.3.3 The water supply shall provide the required pressure for hose connections at the highest elevation.

11.8 Manual Fire-Fighting Equipment.

11.8.1* Fire-fighting equipment shall be provided in accordance with NFPA 600 and NFPA 241.

11.8.2 Portable fire extinguishers of the required capacity shall be provided in accordance with NFPA 10 where one or more of the following conditions exist:

(1) Flammable liquids are stored or handled.
(2) Combustible materials are stored.
(3) Temporary oil- or gas-fired equipment is used.
(4) A tar or asphalt kettle is used.
(5) Welding or open flames are in use.

11.8.3* A standpipe system shall be provided in any permanent building that has walls erected that are equivalent to two floors in height.

11.8.3.1 Additional standpipe hose connections shall be added to each floor level as soon as sufficient landings are available to fight fires from that level.

11.8.3.2 Protection from freezing shall be provided.

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

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

Annex A Explanatory Material

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

A.1.1 This standard does not address water-moderated or water-cooled nuclear reactors used for training, testing, experimental purposes or the production of special nuclear materials as defined in the Atomic Energy Act of 1954, as amended. Refer to NFPA 801.

This standard does not address light water nuclear power plants with construction permits issued prior to January 1, 1979.

An advanced nuclear reactor electric generator station that has opted to use a risk-informed, performance-based approach to fire protection will use NFPA 806 to determine the acceptability of that change.

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

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

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

A.3.3.1 Advanced Light Water Reactors (ALWRs). The two types of reactors follow:

(1) Evolutionary plants, which are simpler, improved versions of conventional designs employing active safety systems.

(2) Revolutionary plants, which are the result of a complete rethinking of the design philosophy of conventional plants. Revolutionary plants currently being proposed replace mechanical safe shutdown systems with passive features that rely on physical properties such as natural circulation, gravity flow, and heat sink capabilities.

Principal examples of evolutionary plant design include the General Electric advanced boiling water reactor (ABWR), the Westinghouse advanced pressurized water reactor (APWR), and the Asea Brown Boveri-Combustion Engineering System 80+ reactor. Principal examples of revolutionary plant design include the General Electric simplified boiling water reactor (SBWR) and the Westinghouse AP-600.

A.3.3.3 Associated Circuits of Concern. These circuits can have any of the following characteristics:

(1) *Type I.* A common power source with a required circuit in which the power source is not electrically protected from the nonrequired circuit by coordinated circuit breakers, fuses, or similar devices

(2) *Type II.* A connection to equipment whose spurious operation could adversely affect safe shutdown capability

(3) *Type III.* A common enclosure (e.g., cable tray, conduit, panel, or junction box) with a required circuit and either of the following:

  (a) Is not electrically protected by circuit breakers, fuses, or similar devices
  (b) Could allow propagation of fire into the common enclosure

A.3.3.8 Defense-in-Depth. None of the fire protection defense-in-depth elements is complete by itself. Strengthening any defense-in-depth element can compensate for known or unknown weaknesses in the other factors.

A.3.3.9 Fire Area. The definition provided in Chapter 3 is the preferred NFPA definition. For the purposes of this standard, the following definition is more specific as to how this term is used: That portion of a building or plant sufficiently bounded to withstand the fire hazards associated with the area and, as necessary, to protect important equipment within the area from a fire outside the area. [**805,** 2020]

A.3.3.10 Fire Area Subdivision. The term *fire zone* typically has been used to address both portions of fire areas and divisions of suppression and detection systems. To provide clarity, this standard uses two separate terms: *fire area subdivision* and *fire zone.* It should be noted that there might be cases in which these two terms could be describing the same location. An example might include a pump bay with concrete barriers (but without all penetrations sealed) that is protected by its own sprinkler system and the detection system that annunciates an alarm specifically for the pump bay. It would be acceptable to describe such a location as both a fire area subdivision and a fire zone.

A.3.3.17 Fire Resistance Rating. The test method is used in ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials.*

A.3.3.22 Fire-Safe Shutdown Component. Such components are not necessarily nuclear safety related.

A.3.3.23 First Break. The first break could be a conduit, a pull box, a junction box, or an electrical panel at the equipment or open ended with cables exiting into a tray.

A.3.3.28 High-Low Pressure Interface. Fire-induced faults on the valve(s) circuitry can cause the loss of the ability to close the valve(s) or the spurious opening of the valve(s), thereby inducing a loss-of-coolant accident or overpressurization of the low-pressure system.

A.3.3.29 Industrial Fire Brigade. Fire brigades can be staffed by shift personnel with collateral responsibilities or by personnel whose primary responsibility is fire-fighting activities (a plant fire department).

A.3.3.33 Nuclear Safety Function. These guidelines can be found in 10 CFR 100, "Reactor Site Criteria."

A.3.3.34 Nuclear Safety Related. These guidelines can be found in 10 CFR 100, "Reactor Site Criteria."

A.3.3.36 Power Block. Examples of power block structures are containment building, auxiliary building, service building, control building, fuel building, rad waste, water treatment, turbine building, and intake structure.

A.3.3.39 Safety Division. The terms *division*, *train*, and *separation group* are interchangeable when used in the context of this definition.

A.3.3.40 Spurious Operation. These operations include but are not limited to the following:

(1) Opening or closing of normally closed or open valves
(2) Starting or stopping of pumps or motors
(3) Actuation of logic circuits
(4) Inaccurate instrument reading

A.4.1 This chapter establishes the criteria for an integrated combination of components, procedures, and personnel to carry out all activities involved in the fire protection program. It includes system and facility design, fire prevention, fire detection, notification, confinement, suppression, administrative controls, fire brigade organization, inspection and maintenance, training, quality assurance, and testing. The intent of this chapter can be met by incorporating the features of this chapter in the safety analysis reports, operating procedures, program manual, policy documents, and other verifiable records as plant management determines.

A.4.4 Where any of the analyses in Section 4.4 have been performed elsewhere, they need only to be referenced as part of the fire hazards analysis.

A.4.4.2(2) A subdivision inventory or table should be prepared and maintained for each fire area. All in situ combustible and flammable materials and their configurations should be identified. Where the in situ combustibles present an exposure to nuclear safety–related systems and components, they should be uniquely identified. Transient combustibles that are expected to be in place during normal plant-operating modes also should be identified. The combustible storage areas should not present a threat to nuclear safety–related systems and components.

A.4.6.1(2) Inspections, tests, administrative controls, fire drills, and training that goveru the fire protection program should be prescribed by documented instructions, procedures, or drawings and should be accomplished in accordance with those documents.

A.4.6.1(3) Measures should be established to ensure that purchased material, equipment, and services conform to the procurement documents.

A.4.6.1(4) A program for independent inspection of activities affecting fire protection should be established and executed by or for the organization performing the activity to verify conformance with documented installation drawings and test procedures for accomplishing the activities.

A.4.6.1(5) A test program should be established and implemented to ensure that testing is performed and verified by inspection and audit to demonstrate conformance with design and system readiness requirements. The tests should be performed in accordance with written test procedures, and test results should be properly evaluated and acted on.

A.4.6.1(6) Measures should be established to provide for the identification of items that have satisfactorily passed necessary tests and inspections.

A.4.6.1(7) Measures should be established to control items that do not conform to specified requirements to prevent inadvertent use or installation.

A.4.6.1(8) Measures should be established to ensure that conditions adverse to fire protection, such as failures, malfunctions, deficiencies, deviations, defective components, uncontrolled combustible material, and nonconformances, are promptly identified, reported, and corrected.

A.4.6.1(9) Records should be prepared and maintained to furnish evidence that the criteria enumerated in 4.6.1 are being met for activities affecting the fire protection program.

A.4.6.1(10) Audits should be conducted and documented to verify compliance with the fire protection program, including design and procurement documents, instructions, procedures and drawings, and inspection and test activities.

A.5.1 This chapter sets forth the minimum requirements necessary for administrative controls and fire prevention activities. It applies to both normal operating modes and extended plant outages when fuel is removed from the reactor. However, additional requirements might be necessary during outages.

Plant outages can create conditions not specifically addressed by the administrative controls and fire prevention practices established in Chapter 5. Fire protection personnel should participate in outage planning to determine if unusual challenges will be presented to the fire protection program. Plans should be developed to address conditions not covered by existing procedures. In addition, extra vigilance to adherence to administrative controls is important during outages. The amount of work activities occurring during outages increases the risk of fire during this time.

A.5.3.1 Combustible materials in both large and small concentrations will be present in nuclear power plants, as in most other industrial plants, and it should be assumed that outbreaks of fire occur for a variety of reasons.

A.5.3.1.1 Typical examples of flammable and combustible materials found in a nuclear power plant include the following:

(1) Conventional fuels for emergency power units, auxiliary boilers, and so forth
(2) Lubricants and hydraulic oils
(3) Insulating materials (thermal and electric)
(4) Building materials (including PVC and other plastics)
(5) Filtering materials (oil-bath filters, charcoal, etc.)
(6) Cleansing materials
(7) Paints and solvents

(8) Packaging materials (bitumen, etc.)
(9) Neutron shields (if organic materials)
(10) Clothing

Typical examples of flammable gases found in a nuclear power plant include the following:

(1) Hydrogen for generator cooling, for coolant conditioning of pressurized water and gas-cooled reactors, and from battery charging
(2) Propane or other fuel gases
(3) Hydrogen (H_2) by radiolysis in the core and addition of H_2 for improved recombination
(4) Gas for cutting and welding
(5) Oxygen (O_2) (not a flammable gas, but an oxidizer, which requires similar controls)

Typical examples of radioactive substances external to the reactor include the following:

(1) Sealed radioactive materials, such as irradiated or plutonium-containing fuel elements, irradiated control rods, neutron sources, and so forth
(2) Unsealed radioactive material, such as ion exchanger fillings and filter cartridges that have become loaded with radioactive substances, rad waste materials, and so forth
(3) Dry low-level radioactive waste

A.5.3.1.2 Typical examples include the following:

(1) Replacement of lubricating or hydraulic oils
(2) Repainting equipment or structures
(3) Replacement of combustible filter materials
(4) Scaffolding or dunnage necessary to maintain or replace equipment
(5) Spare equipment in shipping crates or boxes awaiting installation

A.5.3.3.1 The control of temporary fire loads in the plant is essential to provide defense-in-depth protection. This includes controlling the use of temporary buildings, including trailers, shacks, or shanties within the confines of the plant; the use of noncombustible scaffolds, formwork, decking, and partitions both inside and outside permanent buildings; and the use of noncombustible tarpaulins.

All combustible packing containers should be removed from the area immediately following unpacking. No such combustible material should be left unattended during lunch breaks, shift changes, or other similar periods. Loose combustible packing material such as wood or paper excelsior, polyethylene sheeting, or expanded polystyrene should be placed in metal containers with tight-fitting, self-closing metal covers.

A.5.3.3.4 Particular attention should be given to the control of halogenated plastics.

A.5.3.4.6(1) Oil pipes should be located below steam lines.

A.5.4.2.3 If welding operations have been conducted during the previous work period, the oncoming watchperson should be alerted to check the location where welding was done, as part of regular rounds. Where watch service is not provided, use of gas-operated welding or cutting equipment should be discontinued a minimum of 1 hour before quitting time. Where practical, work should be moved to a safe location to be welded. Torches should not be used to cut holes in walls, floors, ceilings, or roofs containing combustible insulation, framing, sheathing, or finished material.

A.5.5.1.1 Grouped noncombustible buildings, trailers, and sheds with separation between individual units less than that specified by NFPA 80A or grouped combustible or limited-combustible buildings, trailers, or sheds with separation between individual units less than 30 ft (9.1 m) should be considered as a single building. *(See NFPA 80A.)*

A.5.6.1 The impairment procedure should include all of the following:

(1) Identification of equipment that is not available for service
(2) List of those to be notified of impairments (e.g., operations personnel, plant fire brigade personnel, insurance company)
(3) Compensatory measures (e.g., increased surveillance on other systems, fire watch patrols)
(4) Target durations for impaired equipment (e.g., escalation of management attention to impaired equipment to ensure prompt corrective action)
(5) Consideration of plant status (e.g., compensatory measures that can be relaxed for impairment of certain systems during outage conditions)

This list can be modified as needed to include site-specific actions or regulatory commitments.

While impairments to fire protection systems protecting both safe shutdown areas and balance of plant areas are to be included in the procedure, there might be differences in various aspects of the programs (e.g., compensatory measures might be more stringent for impaired systems protecting safe shutdown equipment).

A.5.6.2 When impairments are planned, the necessary equipment and personnel for the repair or service should be staged in advance. When the impairment is unplanned, those responsible for fire protection should ensure that the repair is given the appropriate priority and should bring delays in repair to management's attention.

A.5.6.3 Postmaintenance testing of a system prior to return to service after an impairment is critical to ensure proper functioning. This is not necessary in cases where there was no actual repair or modification work performed on the impaired system. The appropriate level of testing should be established by those most knowledgeable of the impaired system. Section 5.7 and the appropriate NFPA standard addressing the type of system impaired should be used in consideration of the type of postmaintenance testing that is necessary.

A.5.7.3 Normally NFPA standards are used to determine the frequency and type of inspection, testing, and maintenance performed on systems installed for fire protection. Table A.5.7.3 is provided as a reference for this purpose. However, there are considerations and configurations at nuclear power plants that might make it difficult or impracticable to follow the exact requirements of the NFPA standard. In such situations, those responsible for fire protection at the plant need to establish the appropriate inspection, testing, and maintenance frequency and type. For example, fire protection systems installed in containment or high-radiation areas might be accessible only during outages. Water disposal considerations might limit certain sprinkler system tests within radioactive controlled areas.

Table A.5.7.3 Reference Guide for Fire Equipment Inspection, Testing, and Maintenance

Item	NFPA Document
Supervisory and fire alarm circuits	72
Fire detectors	72
Manual fire alarms	72
Sprinkler water flow alarms	25, 72
Sprinkler and water spray systems	15, 25
Foam systems	11, 16
Halogenated agent, chemical, and CO_2 systems	12, 12A, 17
Fire pumps and booster pumps	20
Water tanks and alarms	22, 25, 72
PIVs and OS&Y valves	25, 72
Fire hose and standpipes	14, 1962
Portable fire extinguishers and hose nozzles	10, 1962
Fire doors	80
Smoke vents	204
Emergency lighting	70
Radio communication equipment	1221
Audible and visual signals	72

A.5.7.5 Certain plant systems and equipment, including the turbine generator, transformers, large pumps, and so forth, will have a significant impact on the level of fire risk at a plant. While typically there are programs in place to perform inspections, tests, and maintenance of these systems, those responsible for fire protection should ensure that such inspections, tests, and maintenance are adequate to minimize the fire risk.

A.5.7.6 Fire protection systems should be tested in accordance with NFPA 4 or equivalent standard.

A.6.1.2 Water drainage methods should be reviewed and included in the area's prefire plans.

A.6.1.4 Consideration should be given to providing prefire plans to public fire departments that might respond to the site, to assist them in the development of their own prefire plans.

A.6.2 The focus of the plant fire brigade is to respond to fires that could impair the ability to safely shut down the plant. Response by the fire brigade to fires and alarms on the owner-controlled property but outside the power block is acceptable. Consideration should be given to such factors as the following:

(1) Proximity and response capability of local fire departments
(2) Monetary value of other on-site facilities
(3) Potential for off-site radioactive material release (e.g., low-level radioactive waste facilities)
(4) Potential for impact on plant operations due to fire loss (e.g., low lead time items in warehouse)

Prefire plans should detail radiologically hazardous areas and radiation protection barriers. Methods of smoke and heat removal should be identified for all fire areas in the prefire plans. The methods can include the use of dedicated smoke and heat removal systems or the use of the structure's HVAC system if it can operate in the 100 percent exhaust mode.

A.6.3.1.2 This training includes radioactivity and health physics considerations to ensure that each member is thoroughly familiar with the steps to be taken in the event of a fire; this training will contribute to maintaining the best possible preparedness for such contingencies.

A.6.4.1 This equipment would include but not be limited to protective clothing, respiratory protective equipment, radiation monitoring equipment, personal dosimeters, and fire suppression equipment such as hoses, nozzles, fire extinguishers, and so forth.

A.6.5.2.3 Training of the plant fire brigade should be coordinated with the local fire department so that responsibilities and duties are delineated in advance. This coordination should be part of the training course and should be included in the training of the local fire department staff.

Local fire departments should be provided training in operational precautions when fighting fires on nuclear power plant sites and should be made aware of the need for radiological protection of personnel and the special hazards associated with a nuclear power plant site.

A.6.5.3.1 Duties of the person in this position should include overseeing the issuance of security badges, film badges, and dosimetry to the responding public fire-fighting forces and ensuring that the responding off-site fire department(s) are escorted to the designated point of entry to the plant.

A.6.9 Methods of manual smoke and heat removal should consider the use of portable ventilation equipment as well as the natural migration of smoke and heat due to either natural or mechanical air movement within the building or buildings.

A.7.1 Ensuring the safety of the public, the environment, and plant personnel during and after a fire event is paramount to this standard. The purpose of this chapter is to define the minimum criteria necessary to ensure that the reactor and any support facilities are capable of achieving and maintaining safe plant conditions in the event of a fire and minimizing the release of radioactive material.

A.7.2.2.2 See Figure A.7.2.2.2.

A.7.2.3.1 Currently available examination processes are the fire-induced vulnerability evaluation (FIVE) methodology and the fire probabilistic risk assessment (PRA).

A.7.2.3.2 The value of 1×10^{-6} per reactor year is based on NRC Generic Letter 88-20, Supplement 4.

A.7.3.1.2 These components include nuclear safety–related and safe shutdown components. Components outside the fire area that are electrically or mechanically dependent on fire-damaged components within the fire area should be considered in the analysis.

A.7.3.1.3 This can be accomplished by the use of rated barriers, fire-rated cables, an electrical raceway fire barrier system, physical separation, or a combination of these methods.

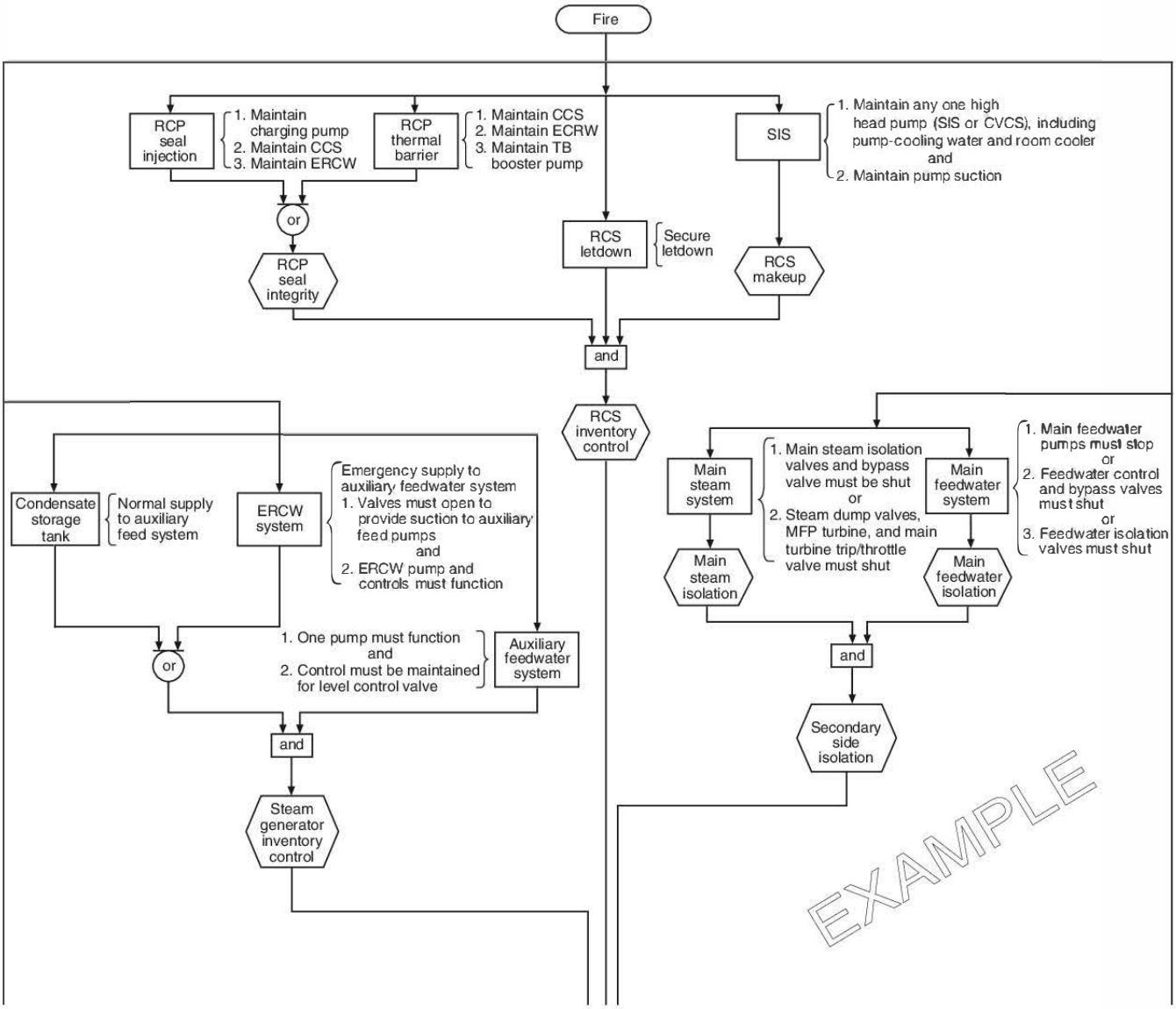
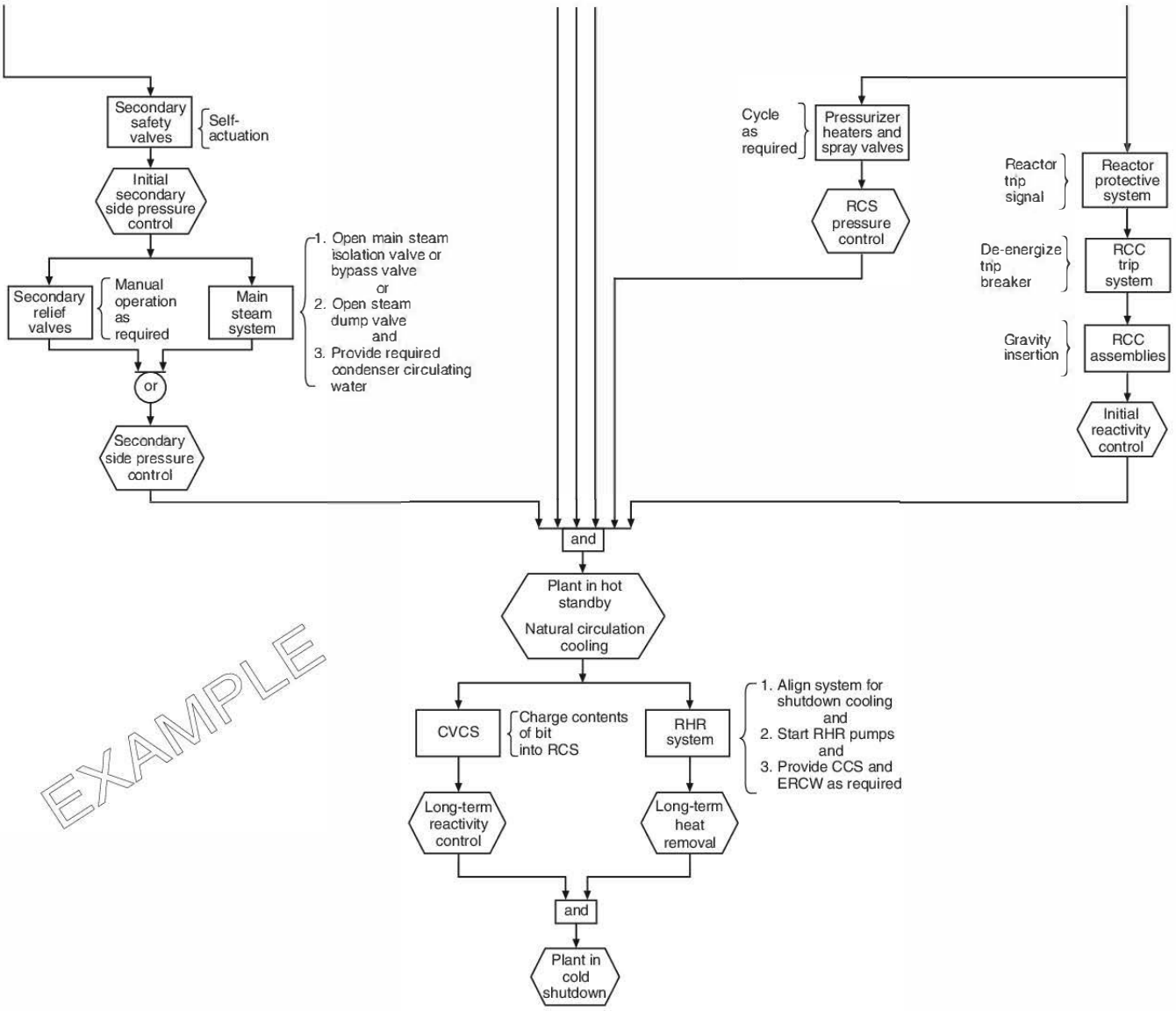


FIGURE A.7.2.2.2 Typical Shutdown Logic Diagram — Fire. (Source: ANS 59.4, *Generic Requirements for Light Water Nuclear Power Plant Fire Protection.*)



Abbreviations:

CCS = component cooling system
CVCS = chemical and volume control system
ERCW = emergency realtor cooling water
MFP = main feed pump
RCC = realtor component cooling
RCP = realtor cooling pump
RCS = realtor cooling system
RHR = residual heat removal
SIS = safety injection system
TB = thermal barrier

Notes:

(1) Train assignment and coherence must be considered before a path can be declared successful.
(2) Adequate lighting for operator action and fire fighting is required.
(3) Habitability for operator and fire fighters is required.

FIGURE A.7.2.2.2 *Continued*

A.7.3.1.8 Appropriate goals and objectives should include the following:

(1) *Nuclear Safety Goal.* The nuclear safety goal should be to provide reasonable assurance that a fire during any operational mode and plant configuration will not prevent the plant from achieving and maintaining the reactor core in a safe and stable condition.
(2) *Radioactive Release Goal.* The radioactive release goal should be to provide reasonable assurance that a fire will not result in a radiological release that adversely affects the public, plant personnel, or the environment.

Appropriate performance objectives should include:

(1) Nuclear Safety Objectives. In the event of a fire during any operational mode and plant configuration, the plant shall be as follows:
    (a) Reactivity Control. Capable of achieving and maintaining subcritical conditions.
    (b) Fuel Cooling. Capable of achieving and maintaining decay heat removal.
    (c) Fission Product Boundary. Capable of preventing fuel damage.
    (d) Heat transfer medium inventory control. Capable of maintaining the necessary quantity of heat transfer medium.

Appropriate radioactive release objectives should include:

The source term from sources not including fuel in the core is capable of being limited.

Appropriate performance criteria should include:

(1) *Nuclear Safety Performance Criteria.* Fire protection features should be capable of providing reasonable assurance that, in the event of a fire, the plant is not placed in an unrecoverable condition. To demonstrate this, the following performance criteria should be met.
    (a) *Reactivity Control.* Reactivity control should be capable of inserting negative reactivity to achieve and maintain sub-critical conditions. Negative reactivity inserting should occur rapidly enough such that fuel design limits are not exceeded.
    (b) *Fission Product Boundary.* The fundamental geometric relationship between the fuel and the moderator is maintained such that reactivity control and decay heat removal can be accomplished.
    (c) *Heat Transfer Medium Inventory Control.* The heat transfer medium utilized by the reactor should be maintained in sufficient quantity to ensure that decay heat removal can be accomplished.
    (d) *Decay Heat Removal.* Decay heat removal should be capable of removing sufficient heat from the reactor core and spent fuel such that they are maintained in a safe and stable condition.
    (e) *Vital Auxiliaries.* Vital auxiliaries should be capable of providing the necessary auxiliary support equipment and systems to ensure that the systems required under the other five items in this sublist are capable of performing their required nuclear safety function.
    (f) *Process Monitoring.* Process monitoring should be capable of providing the necessary indication to ensure that the criteria addressed in the first five items in this sublist have been achieved and are being maintained.
(2) *Radioactive Release Performance Criteria.* Radiation release to any unrestricted area due to the direct effects of fire suppression activities (but not involving fuel damage to fuel in the core during operation) should be as low as reasonably achievable and should not exceed applicable regulatory limits.

A.7.3.1.12 For three-phase ac circuits, the probability of getting a hot short on all three phases in the proper sequence to cause spurious operation of a motor is considered sufficiently low, and additional evaluation, except for the case involving high-to-low pressure interface, is not necessary.

A.7.3.1.14 These devices protect the function of the safety circuit in the event of fire damage to the associated circuits of concern.

A.7.3.1.15 Associated circuits of concern not necessary to achieve safe shutdown might be found to share a common enclosure. Fire-initiated electrical fault currents could be generated on unprotected nonsafe shutdown cables. If a fault current is of sufficient magnitude, a secondary fire might be initiated in the common enclosure shared with shutdown cable.

A.7.3.2 Review of seismic-induced fire experience data performed by the Electric Power Research Institute (EPRI), the Seismic Qualification Utilities Group (SQUG), and others suggests there is minimal threat of seismic-induced fires in nuclear power plants. Review of more than 100 power plant and industrial sites in 18 strong ground-motion earthquakes revealed only 4 instances of seismic-induced fires. The causes of these fires were attributed to arcing of high-voltage equipment, chemical laboratory fire, and oil-soaked insulation on piping. This low incidence of approximately 4 percent represents installations primarily in high-seismic-hazard regions designed to commercial and industrial codes and standards.

A.7.3.2.2 Guidance is provided in NRC Generic Letter 88-20, Supplement 4, "Sandia Risk Scoping Items."

A.7.5.2.2 Repairs such as lifting leads or pulling of fuses should not be necessary to achieve shutdown of the reactor.

A.7.5.3.1.1 Stairwells in such routes should be enclosed in masonry or concrete towers with a minimum fire rating of 2 hours and should be provided with self-closing, Class B fire doors. The stairwells should be designed with smoke control features.

A.7.5.3.2.1 Operators should not be required to perform any unsafe physical actions.

A.7.5.3.2.2 Operators should not be required to perform any physical operations that are outside their normal physical abilities.

A.8.2.1 Conformance with NFPA *101* satisfies Occupational Safety and Health Administration (OSHA) requirements for means of egress.

A.8.2.2 The operation and maintenance of an ALWR plant involves unique operations and materials in process.

A.8.3.2 Many plastic materials, including flame- and fire-retardant materials, will burn with an intensity and energy production in the range similar to that of ordinary hydrocar-

bons. When burning, they produce heavy smoke that obscures visibility and can plug air filters, especially charcoal and high-efficiency particulate air (HEPA) filters. The halogenated plastics also release free chloride and hydrogen chloride when burning, which are toxic to humans and corrosive to equipment.

A.8.3.4.1 The provisions of 8.3.4.1 do not require inherently noncombustible materials to be tested in order to be classified as noncombustible materials. [*101*:A.4.6.13]

A.8.3.4.1.1(1) Examples of such materials include steel, concrete, masonry, and glass. [*101*:A.4.6.13.1(1)]

A.8.3.4.2 Materials subject to increase in combustibility or flame spread index beyond the limits herein established through the effects of age, moisture, or other atmospheric condition are considered combustible. *(See NFPA 259 and NFPA 220.)* [*101*:A.4.6.14]

A.8.3.8.2 This will minimize the possibility of wall penetration in the event of a container failure.

A.8.4 Suitable design of the ventilation system can limit the consequences of a fire by preventing the spread of the products of combustion to other fire areas. The design of the ventilation system should provide a means to ventilate, exhaust, or isolate the fire area as necessary, and consideration should be given to the consequences of failure of the ventilation system due to fire causing loss of control for ventilating, exhausting, or isolating a given fire area. The capability to ventilate, exhaust, or isolate is particularly important to ensure the habitability of rooms and spaces that should be attended in the fire emergency. In the design, provisions should be made for personnel access to and escape routes from each fire area.

A.8.4.1 For further information, see NFPA 92 and NFPA 204.

A.8.4.2 The need for automatic dampers or shutdown can be avoided by installing separate ventilation systems for each fire area or by installing fire-resistive ducting enclosures. Additional filter protection might be necessary.

A.8.4.3.4 This includes containment functions for protecting the public and maintaining habitability for operations personnel.

A.8.4.6 The purpose of this subsection is to minimize the possibility of contaminating the air intake with the products of combustion.

A.8.4.8.2 Figure A.8.4.8.2 shows a typical air duct fire damper configuration.

A.8.5.1 Refer to Annex A of NFPA 15 for additional information on drainage.

A.8.5.3(3) Brazed, soldered, and clamp-type fittings as well as nonferrous and plastic piping are susceptible to melting under fire conditions. Ferrous piping, where internal liquids are confined, is subject to bursting under fire conditions.

A.8.9 See NFPA 80A.

A.8.11.2 Multichannel portable radios are used for communications at nuclear power plants. Subsections 8.11.2 and 8.11.3 do not prohibit sharing of radio channels by various station groups. The use and assignment of channels should ensure that the fire brigade, operations, and security all can use the radios to carry out their functions during a fire emergency.

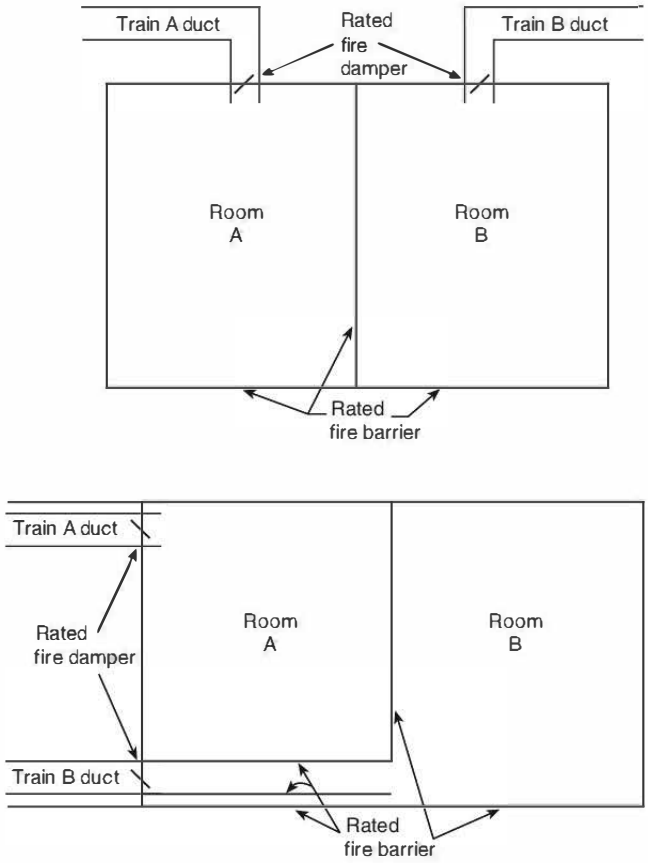


FIGURE A.8.4.8.2 Typical Air Duct Fire Damper Configuration.

A.8.11.6 In unique or unusual circumstances where equipment cannot be designed to prevent radio frequency interference, the authority having jurisdiction can permit the area around the sensitive equipment where portable radios cannot be used to be identified and marked so that fire fighters can readily recognize the condition. Training in this recognition also should be provided.

A.9.1.1 Automatic sprinkler protection provides the best means for controlling fires and should be provided. Special hazards might necessitate additional fixed protection systems as indicated by the fire hazards analysis.

A.9.1.2 Mitigating severe accident events that can result in fuel-clad damage is a top priority. Because fires and other severe plant accidents are not assumed to occur simultaneously, fire protection systems do not need to be designed to handle both demands simultaneously.

A.9.2.1 The water supply for the permanent fire protection water system should be based on providing a 2-hour water supply for both items 9.2.1(1) and 9.2.1(2), as follows:

(1) Either item (a) or (b), whichever is larger:

(a) The largest fixed fire suppression system demand

(b) Any fixed fire suppression system demand that could be reasonably expected to operate simultaneously during a single event (e.g., turbine underfloor

protection in conjunction with other fire protection systems in the turbine area)

(2) The hose stream demand of not less than 500 gpm (1892.5 L/min)

A.9.2.2 Due to the 100 percent redundancy feature of two tanks, refill times in excess of 8 hours are acceptable.

A.9.2.3 The intent of this paragraph is to provide a water supply that will not be susceptible to biofouling, scaling, microbiologically induced corrosion (MIC), or sedimentation.

A.9.2.4.2 For maximum reliability, three fire pumps should be provided so that two pumps meet the maximum demand plus hose streams. Two fire pumps could be an acceptable alternative, provided either of the fire pumps can supply the maximum demand plus hose streams within 120 percent of the fire pump's rated capacity.

A.9.3 See Chapter 5.

A.9.4.1 NFPA 24 gives necessary guidance for such installation. It references other design codes and standards developed by such organizations as the American National Standards Institute (ANSI) and the American Water Works Association (AWWA).

A.9.4.4 A common yard fire main loop can serve multiunit nuclear power plant sites if it is cross-connected between units.

A.9.4.10 Guidance on safe distances for water application to live electrical equipment can be found in the NFPA *Fire Protection Handbook*.

A.9.4.11.1 The water supply for this condition is permitted to be obtained by manual operator actuation of valves in a connection to the hose standpipe header from a normal seismic Category 1 water system such as the essential service water system.

A.9.7.3 This is also referred to as a Class A system.

A.9.7.5 Visual signaling appliances can be used to supplement audible appliances in the protected area. *(See NFPA 72.)*

A.9.7.8 See *NFPA 72*.

A.10.1 Examples of such hazards include lubricating oil or hydraulic fluid systems for the primary coolant pumps, cable tray arrangements and cable penetration, and charcoal filters. Because of the general inaccessibility of the primary containment during normal plant operation, protection should be provided by automatic fixed suppression systems. The effects of postulated fires within the primary containment should be evaluated to ensure that the integrity of the primary coolant system and the containment are not jeopardized, assuming no manual action is taken to fight the fire.

A.10.2.1.10 A flame arrester is required in the vent if the flash point characteristics of the oil present the hazard of fire flashback.

A.10.2.2.1 Refueling and maintenance operations in containment might introduce additional hazards such as containment control materials, decontamination supplies, wood planking, temporary wiring, welding, and flame cutting (with portable compressed-gas fuel supply). Possible fires would not necessarily be in the vicinity of the installed fire detector and suppression systems.

A.10.4.1.4(4) It might be beneficial to provide continuous line-type heat detectors in the cable trays where the cable trays are stacked more than three cable trays high or over 18 in. (457.2 mm) wide, in addition to the area smoke detection systems.

A.10.4.2.1 It might be beneficial to provide continuous line-type heat detectors in the cable trays where the cable trays are stacked more than three cable trays high or over 18 in. (457.2 mm) wide, in addition to the area smoke detection systems.

A.10.6.1 Switchgear should be raised off the floor.

A.10.6.2 See Section 8.4.

A.10.7.1 For further information, refer to IEEE 484, *Recommended Practice for Installation Design and Installation of Large Lead Batteries for Generating Stations and Substations*.

A.10.8.1 Smoke and heat vents or sprinkler protection at the roof level is necessary to protect the turbine building structure.

A.10.8.2.1 To avoid water application to hot parts or other water-sensitive areas and to provide adequate coverage, designs that incorporate items such as fusible element operated spray nozzles might be necessary.

A.10.8.3 Additional information concerning turbine generator fire protection can be found in EPRI Research Report 1843-2, "Turbine Generator Fire Protection by Sprinkler System."

A.10.8.8 This area generally represents the largest concentrated oil storage area in the plant.

A.10.8.9.1 For hydrogen storage systems, see NFPA 55. For electrical equipment in the vicinity of the hydrogen-handling equipment, including detraining equipment, seal oil pumps, valves, and so forth, see Article 500 of *NFPA 70* and Section 127 of ANSI/IEEE C2, *National Electrical Safety Code*.

A.10.8.9.1.1 This minimizes the potential for a major discharge of hydrogen in the event of a leak from piping inside the plant.

A.10.8.9.1.6 The preferable arrangement from a fire risk standpoint is to keep the bulk storage isolated from the generator by shutting the block valve outdoors. Makeup should be done manually as necessary, logging hydrogen usage to track consumption. This procedure allows for an ongoing indication of what is being used, and it prevents the system from feeding hydrogen during a fire emergency if there is a failure at one of the generator shaft seals.

A.10.8.11 It is desirable to provide for remote operation, preferably from the control room, of the condenser vacuum break valve and the lubricating pumps. Breaking the condenser vacuum markedly reduces the rundown time for the turbine generator and thus limits oil discharge in the event of a leak.

A.10.8.11.4(2) On some turbine generators employing the guard pipe principle, the guard piping arrangement terminates under the machine housing where feed and return piping run to pairs of bearings. Such locations are vulnerable to breakage with attendant release of oil in the event of excessive vibration and should be protected.

A.10.10.1 Underground tanks are acceptable outside or under buildings. *(See NFPA 30 for additional guidance.)*

A.10.23.4 See Article 450 of *NFPA 70*.

A.11.1 Although many of the activities at nuclear power generating plant construction sites are similar to those at 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, the high value of materials, and the duration of the construction period. An example of a multimillion dollar fire that resulted in significant property damage, construction delays, and other complications follows.

In 1971, a fire occurred in the primary auxiliary building of a U.S. nuclear power plant under construction. The fire originated in a combustible construction shed. At the time of the fire, nuclear fuel had been loaded and the reactor vessel head was removed. The fire spread to the cable system and caused considerable damage to three motor control centers, which provided power to many of the engineered safety features. The two-hour fire was fought by the off-site fire departments from three local communities. Arson was suspected to have been the cause of this $2,100,000 fire, which delayed the startup of the plant.

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

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

A.11.2.7 The first round should be conducted one-half hour after the suspension of work for the day. Thereafter, rounds should be made every hour. Where partial construction activities occur on second and third shifts, the guard service rounds can be modified to include only unattended or sparsely attended areas. 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 can be omitted after the first round. *(See NFPA 601.)*

A.11.3.1.6 Local conditions might require the establishment of firebreaks by clearing or by use of selective herbicides in areas adjacent to property lines and access roads.

A.11.4.2 For guidance in separation and protection, see NFPA 80A.

A.11.4.3 Large central office facilities can be of substantial value and contain high-value computer equipment, irreplaceable construction records, or other valuable contents, the loss of which can result in significant construction delays.

This evaluation might indicate a need for automatic sprinkler systems or other protection or the desirability of subdividing the complex to limit values exposed by one fire.

A.11.4.4.4 Air-supported structures sometimes are used to provide temporary warehousing space. Although the fabric envelope could be a fire-retardant material, the combustibility of contents and their 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 consideration is that relatively minor fire damage to the fabric envelope might leave the contents exposed to the elements.

A.11.6.1 The use of noncombustible or fire-retardant concrete formwork is especially important for large structures (e.g., reactor building and turbine generator pedestal) where large quantities of forms are used.

A.11.6.2 Pressure-impregnated fire-retardant lumber should be used in accordance with its listing and the manufacturers' instructions. Where exposed to the weather or moisture (e.g., on concrete forms), the fire retardant used should be suitable for the exposure. Fire-retardant coatings are not acceptable on walking surfaces or surfaces subject to mechanical damage.

A.11.7.1 The necessary reliability of construction water supplies, including redundant pumps, arrangement of power supplies, and use of combination service water and construction fire protection water, should be determined by the individual responsible for fire protection.

A.11.7.3.2 The extinguishing system should provide at least some degree of protection, especially where the full hazard is not yet present.

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

A.11.8.3 See NFPA 14.

Annex B Best Practices for Protection of Fire and Explosion Hazards in Nuclear Reactor Power Plants

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

B.1 General.

B.1.1 Scope. The scope of this annex is to provide guidance on best practices for the protection of fire and explosion hazards in nuclear reactor power plants.

B.1.2 Purpose. Fire protection systems might be required by the fire hazards analysis to reduce the potential effects of fire on plant equipment. This annex provides information on the types of fire protection systems that experience has demonstrated as effective means of providing this protection to various plant areas and equipment.

B.1.3 Application. The identification and selection of fire protection systems in nuclear reactor power plants should be based on the design parameters required as a result of the fire hazards analysis. The selection of extinguishing agent should be based on all of the following:

(1) Type or class of hazard
(2) Effect of agent discharge on critical equipment, such as thermal shock, continued operability, water damage, overpressurization, and cleanup
(3) Health hazards

B.2 Primary and Secondary Containments.

B.2.1 Normal Operation. Fire protection for the primary and secondary containment areas should be provided for hazards identified by the fire hazards analysis.

B.2.1.1 Operation of the fire protection systems should not compromise the integrity of the containment or other safety-related systems. Fire protection systems in the containment

areas should function in conjunction with total containment requirements such as ventilation and control of containment liquid and gaseous release.

B.2.1.2 Inside primary containment, fire detection systems should be provided for each fire hazard identified in the fire hazards analysis. The type of detection used and the location of the detectors should be the most suitable for the particular type of fire hazard identified by the fire hazards analysis.

B.2.1.3 A general area fire detection capability should be provided in the primary containment as a backup for the hazard detection described above. To accomplish this, suitable smoke or heat detectors compatible with the radiation environment should be installed in accordance with *NFPA 72*.

B.2.1.4 Standpipe and hose stations should be installed inside containment. If plant-specific features prevent extending the fire main supply inside containment, standpipe and hose stations inside containment should be permitted to be connected to a high-quality water supply of sufficient quantity and pressure other than the fire main loop.

B.2.1.5 For inerted primary containment, standpipe and hose stations should be permitted to be placed outside the primary containment, with hose no longer than 100 ft (30.5 m), to reach any location inside the primary containment with a 30 ft (9.1 m) effective hose stream.

B.2.1.6 Reactor coolant pumps with an external lubrication system should be provided with an oil collection system. The oil collection system should be so designed, engineered, and installed that failure of the oil collection system will not lead to a fire during normal operations or off-normal conditions such as accident conditions or earthquakes.

B.2.1.7 The oil collection systems should be capable of collecting oil from all potential pressurized and unpressurized leakage sites in the reactor coolant pump oil systems. Leakage should be collected and drained to a vented closed container that can hold the entire oil system inventory. Leakage points to be protected should include the lift pump and piping, overflow lines, oil cooler, oil fill and drain lines and plugs, flanged connections on oil lines, and oil reservoirs where such features exist on the reactor coolant pumps. The drain line should be large enough to accommodate the largest potential oil leak.

B.2.2 Refueling and Maintenance. Refueling and maintenance operations in containment can introduce additional hazards such as containment control materials, decontamination supplies, wood planking, temporary wiring, welding, and flame cutting (with portable compressed gas fuel supply). Possible fires would not necessarily be in the vicinity of the installed fire detector and suppression systems.

B.2.2.1 Management procedures and controls necessary to ensure adequate fire protection for fire hazards introduced during maintenance and refueling should be provided. Adequate backup fire suppression should be provided so that total reliance is not placed on a single fire suppression system.

B.2.2.2 Adequate self-contained breathing apparatus should be provided near the containment entrance for fire-fighting and damage control personnel. These units should be independent of any breathing apparatus or air supply systems provided for general plant activities and should be clearly marked as emergency equipment.

B.3 Control Room Complex.

B.3.1 The control room complex (kitchen, office spaces, etc.) should be protected against disabling fire damage and should be separated from other areas of the plant by floors, walls, ceilings, and roofs having a minimum fire resistance rating of 3 hours. Peripheral rooms in the control room complex should have an automatic water-based suppression system where required by the fire hazards analysis and should be separated from the control room by noncombustible construction with a minimum fire resistance rating of 1 hour. Ventilation system openings between the control room and the peripheral rooms should have automatic smoke dampers installed that close on operation of the fire detection and fire suppression systems.

B.3.2 Manual fire-fighting capability should be provided for both of the following:

(1) Fires originating within a cabinet, console, or connecting cables
(2) Exposure fires involving combustibles in the general room area

B.3.3 Portable Class A and Class C fire extinguishers should be located in the control room. A fire hose station should be installed immediately outside the control room.

B.3.4 Nozzles that are compatible with the hazards and the equipment in the control room should be provided for the fire hose stations. The choice of nozzles should satisfy fire-fighting requirements and electrical safety requirements and should minimize physical damage to electrical equipment from hose stream impingement.

B.3.5 Smoke detectors should be provided in the control room complex, the electrical cabinets, and consoles. If redundant safe shutdown equipment is located in the same control room cabinet or console, the cabinet or console should be provided with internal separation (noncombustible barriers) to limit the damage to one safety division.

B.3.6 Breathing apparatus for the control room operators should be readily available.

B.3.7 The outside air intakes for the control room ventilation system should be provided with smoke detection capability to alarm in the control room and enable manual isolation of the control room ventilation system, thus preventing smoke from entering the control room.

B.3.8 Venting of smoke produced by a fire in the control room by means of the normal ventilation system should be permitted to be acceptable; however, provision should be made to permit isolation of the recirculation portion of the normal ventilation system. Manually operated venting of the control room should be available to the operators.

B.3.9 All cables that enter the control room should terminate in the control room. No cabling should be routed through the control room from one area to another. Cables in underfloor spaces and in above-ceiling spaces should meet the separation criteria necessary for fire protection.

B.3.10 Air-handling functions should be ducted separately from cable runs in such spaces (e.g., if cables are routed in underfloor or ceiling spaces, these spaces should not be used as air plenums for ventilation of the control room). Fully enclosed electrical raceways located in such underfloor and ceiling spaces, if over 1 ft^2 (0.09 m^2) in cross-sectional area,

should have automatic fire suppression inside. Area automatic fire suppression should be provided for underfloor and ceiling spaces used for cable runs unless all cables are run in 4 in. (101.6 mm) or smaller steel conduit or cables are in fully enclosed raceways internally protected by automatic fire suppression.

B.4 Cable Concentrations.

B.4.1 Cable Spreading Room.

B.4.1.1 The cable spreading room should have an automatic water-based suppression system. The location of sprinklers or spray nozzles should consider cable tray arrangements to ensure adequate water coverage for areas that could present exposure fire hazards to the cable raceways. Automatic sprinkler systems should be designed for a density of 0.30 gpm/ft^2 (12.2 L/min · m^2) over the most remote 2500 ft^2 (232.2 m^2).

B.4.1.2 Suppression systems should be zoned to limit the area of protection to that which the drainage system can handle with any two adjacent systems actuated. Deluge and water spray systems should be hydraulically designed with each zone calculated with the largest adjacent zone flowing.

B.4.1.3 Cable spreading rooms should have all of the following:

(1) At least two remote and separate entrances for access by the fire brigade personnel.
(2) An aisle separation between tray stacks at least 3 ft (0.9 m) wide and 8 ft (2.4 m) high.
(3) Hose stations and portable fire extinguishers installed immediately outside the room.
(4) Area smoke detection. It might be beneficial to provide continuous line–type heat detectors in the cable trays where the cable trays are stacked more than three cable trays high or over 18 in. (457.2 mm) wide, in addition to the area smoke detection systems.

B.4.2 Cable Tunnels.

B.4.2.1 Detection Systems. Cable tunnels should be provided with smoke detection. It might be beneficial to provide continuous line–type heat detectors in the cable trays where the cable trays are stacked more than three cable trays high or over 18 in. (457.2 mm) wide, in addition to the area smoke detection systems.

B.4.2.2 Suppression Systems.

B.4.2.2.1 Cable tunnels should be provided with automatic fixed suppression systems. Automatic sprinkler systems should be designed for a density of 0.30 gpm/ft^2 (12.2 L/min · m^2) for the most remote 100 linear ft (30.5 m) of cable tunnel up to the most remote 2500 ft^2 (232.2 m^2).

B.4.2.2.2 The location of sprinklers or spray nozzles should consider cable tray arrangements and possible transient combustibles to ensure adequate water coverage for areas that could present exposure fire hazards to the cable raceways.

B.4.2.2.3 Deluge sprinkler systems or deluge spray systems should be zoned to limit the area of protection to that which the drainage system can handle with any two adjacent systems actuated. The systems should be hydraulically designed, with each zone calculated with the largest adjacent zone flowing.

B.4.2.3 Cables should be designed to allow wetting undamaged cables with water supplied by the fire suppression system without electrical faulting.

B.4.2.4 Cable tunnels over 50 ft (15.2 m) long should have all of the following:

(1) At least two remote and separate entrances for access by the fire brigade personnel
(2) An aisle separation between tray stacks at least 3 ft (0.9 m) wide and 8 ft (2.4 m) high
(3) Hose stations and portable fire extinguishers installed immediately outside the tunnel

B.4.3 Cable Shafts and Risers. Cable tray fire breaks should be installed every 20 ft (6.1 m) for vertical cable trays that rise over 30 ft (9.1 m). Access to cable shafts should be provided every 40 ft (12.2 m) with the topmost access within 20 ft (6.1 m) of the cable shaft ceiling. Automatic sprinkler protection and smoke detection should be provided at the ceiling of the vertical shaft.

B.5 Plant Computer and Communication Rooms. Computer and communication rooms should meet the applicable requirements of NFPA 75.

B.6 Switchgear Rooms and Relay Rooms.

B.6.1 Smoke detection should be provided and should alarm in both the control room and locally. Cables entering the safety-related switchgear rooms should terminate in the switchgear room. The safety-related switchgear rooms should not be used for other purposes. Fire hose stations and portable fire extinguishers should be readily available outside the area.

B.6.2 Equipment should be located to facilitate fire fighting. Drains should be provided to prevent water accumulation from damaging safety-related equipment. Remote manually actuated ventilation should be provided for smoke removal when manual fire suppression is needed. *(See Section 6.3.)*

B.7 Battery Rooms.

B.7.1 Battery rooms should be provided with ventilation to limit the concentration of hydrogen to 2 percent by volume. Loss of ventilation should alarm in the control room. For further information, refer to IEEE 484, *Recommended Practice for Installation Design and Installation of Large Lead Batteries for Generating Stations and Substations.*

B.7.2 Safety-related battery rooms should be protected against fires and explosions. Battery rooms should be separated from other areas of the plant by fire barriers having a 1-hour minimum rating. Direct current switchgear and inverters should not be located in these battery rooms. Fire detection should be provided. Fire hose stations and portable fire extinguishers should be readily available outside the room.

B.8 Turbine Building.

B.8.1 The turbine building should be separated from adjacent structures containing safety-related equipment by fire-resistive barriers having a minimum 3-hour rating. The fire barriers should be designed so that the barrier will remain in place even in the event of a complete collapse of the turbine structure.

B.8.1.1 Openings and penetrations should be minimized in the fire barrier and should not be located where turbine oil

systems or generator hydrogen cooling systems create a direct fire exposure hazard to the fire barrier.

B.8.1.2 For those plants provided with complete automatic sprinkler protection at the roof level, smoke and heat removal systems are not required.

B.8.2 Areas Beneath the Turbine Generator Operating Floor.

B.8.2.1 All areas beneath the turbine generator operating floor should be protected by an automatic sprinkler or foam-water sprinkler system. The sprinkler system beneath the turbine generator should take into consideration obstructions from structural members and piping and should be designed to a minimum density of 0.30 gpm/ft^2 (12.2 L/min · m^2) over a minimum application of 5000 ft^2 (464.5 m^2). To avoid water application to hot parts or other water-sensitive areas and to provide adequate coverage, designs that incorporate items such as fusible element–operated spray nozzles might be necessary.

B.8.2.2 Foam-water sprinkler systems installed in place of automatic sprinklers described in B.8.2.1 should be designed in accordance with NFPA 16 and the design densities specified in B.8.2.1.

B.8.2.3 Electrical equipment in the area covered by a water or foam system should be of the enclosed type or otherwise protected to minimize water damage in the event of system operation.

B.8.3 Turbine Generator Bearings. Additional information concerning turbine generator fire protection can be found in EPRI Research Report 1843-2, "Turbine Generator Fire Protection by Sprinkler System," July 1985.

B.8.3.1 Automatic fixed suppression systems should be provided for all turbine generator and exciter bearings. If closed-head water spray systems utilizing directional nozzles in accordance with NFPA 15 are provided, bearing protection should be provided for a minimum density of 0.30 gpm/ft^2 (12.2 L/min · m^2) over the protected area.

B.8.3.2 Accidental water discharge on bearing points and hot turbine parts should be considered. If necessary, these areas should be permitted to be protected by shields and encasing insulation with metal covers.

B.8.4 Lubricating oil lines above the turbine operating floor should be protected with an automatic sprinkler system covering those areas subject to oil accumulation, including the area within the turbine lagging (skirt). The automatic sprinkler system should be designed to a minimum density of 0.30 gpm/ft^2 (12.2 L/min · m^2).

B.8.5 Lubricating oil reservoirs and handling equipment should be protected in accordance with B.8.2.1. If the lubricating oil reservoir is elevated, sprinkler protection should be extended to protect the area beneath the reservoir.

B.8.6 If shaft-driven ventilation systems are not used, the area inside a directly connected exciter housing should be protected with an automatic fire suppression system. If shaft-driven ventilation systems are used, an automatic preaction sprinkler system providing a density of 0.30 gpm/ft^2 (12.2 L/min · m^2) over the entire area should be provided.

B.8.7 Clean or dirty oil storage areas should be protected based on the fire risk evaluation. The designer should consider, as a minimum, the installation of fixed automatic fire protection systems and the ventilation and drainage requirements.

B.8.8 Hydrogen Systems. For hydrogen storage systems, see NFPA 55. For electrical equipment in the vicinity of the hydrogen handling equipment, including detraining equipment, seal oil pumps, valves and so forth, see Article 500 of *NFPA 70* and Section 127 of ANSI/IEEE C2, *National Electrical Safety Code*.

B.8.8.1 General. The preferable arrangement from a fire risk standpoint is to keep the bulk storage isolated from the generator by shutting the block valve outdoors. Makeup should be done manually as necessary, with hydrogen usage logged to track consumption. This procedure allows for an ongoing indication of what is being used, and it prevents the system from feeding hydrogen during a fire emergency if there is a failure at one of the generator shaft seals.

B.8.8.1.1 Bulk hydrogen systems supplying one or more generators should have automatic valves located at the supply and operable by "dead man"–type controls at the generator fill point(s) or operable from the control room. This arrangement minimizes the potential for a major discharge of hydrogen in the event of a leak from piping inside the plant.

B.8.8.1.2 Vented guard piping should be permitted to be used inside the building to protect runs of hydrogen piping.

B.8.8.1.3 A flanged spool piece or equivalent arrangement should be provided to facilitate the separation of hydrogen supply when the generator is open for maintenance.

B.8.8.1.4 Control room alarms should be provided to indicate abnormal gas pressure, temperature, and percentage of hydrogen in the generator.

B.8.8.1.5 The generator hydrogen dump valve and hydrogen detraining equipment should be arranged to vent directly to a safe outside location. The dump valve should be remotely operable from the control room or from an area accessible during a machine fire.

B.8.8.1.6 The generator hydrogen dump valve and hydrogen detraining equipment should be arranged to vent directly to a safe outside location. The dump valve should be remotely operable from the control room or from an area accessible during a machine fire.

B.8.8.2 Hydrogen Seal Oil Pumps.

B.8.8.2.1 Redundant hydrogen seal oil pumps with separate power supplies should be provided for adequate reliability of seal oil supply.

B.8.8.2.2 Where feasible, electrical circuits to redundant pumps should be run in buried conduit or provided with fire-retardant coating if exposed in the area of the turbine generator to minimize the possibility of loss of both pumps as a result of a turbine generator fire.

B.8.8.2.3 Hydrogen seal oil units should be protected by an automatic, open-head water spray system providing a density of 0.30 gpm (1.13 L/min) over the hydrogen seal area.

B.8.8.2.4 Curbing, drainage, or both should be provided for the hydrogen seal oil unit.

B.8.8.3 Hydrogen in Safety-Related Areas.

B.8.8.3.1 Hydrogen lines in safety-related areas either should be designed to seismic Class I requirements or sleeved such

that the outer pipe is directly vented to the outside or should be equipped with excess-flow valves so that, in case of a line break, the hydrogen concentration in the affected areas will not exceed 2 percent.

B.8.8.3.2 Hydrogen lines or sensing lines containing hydrogen should not be piped into or through the control room.

B.8.9 Hydraulic Control Systems. The hydraulic control system should use a listed fire-resistant fluid.

B.8.10 Lubricating Oil Systems. It is desirable to provide for remote operation, preferably from the control room, of the condenser vacuum break valve and the lubricating pumps. Breaking the condenser vacuum markedly reduces the rundown time for the turbine generator and thus limits oil discharge in the event of a leak.

B.8.10.1 Turbine lubricating oil reservoirs should be provided with vapor extractors, which should be vented to a safe outside location.

B.8.10.2 Curbing, drainage, or both should be provided for the turbine lubricating oil reservoir in accordance with Section 6.4.

B.8.10.3 All oil pipe serving the turbine generator should be designed and installed to minimize the possibility of an oil fire in the event of severe turbine vibration.

B.8.10.4 Piping design and installation should consider all of the following measures:

(1) Welded construction
(2) Guard pipe construction with the pressure feed line located inside the return line or in a separate shield pipe drained to the oil reservoir
(3) Routing of oil piping clear of or below steam piping or metal parts
(4) Insulation with impervious lagging for steam piping or hot metal parts under or near oil piping or turbine bearing points

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

B.8.10.5 Cable for operation of the lube oil pumps should be protected from fire exposure. Where feasible, electrical circuits to redundant pumps should be run in buried conduit. Protection should be permitted to consist of separation of cables for ac and dc oil pumps or 1-hour fire-resistive coating (derating of cable should be considered).

B.9 Standby Emergency Diesel Generators and Combustion Turbines.

B.9.1 The installation and operation of standby emergency diesel generators and combustion turbines should be in accordance with NFPA 37.

B.9.2 Automatic shutdown and remote shutdown features should be governed by nuclear safety requirements.

B.9.3 Standby emergency diesel generators and combustion turbines located within main plant structures should be protected by automatic sprinkler, water spray, or foam-water sprinkler systems. Sprinkler and water spray protection systems should be designed for a 0.25 gpm/ft^2 (10.19 L/min · m^2) density over the entire area.

B.9.4 Fire detection should be provided to alarm and annunciate in the control room and to alarm locally. Fire hose stations and portable fire extinguishers should be readily available outside the area. Drainage for fire-fighting water and means for local manual venting of smoke should be provided.

B.9.5 A day tank should be permitted in standby emergency diesel generator and combustion turbine rooms if the day tank is located in a diked enclosure that has sufficient capacity to hold 110 percent of the contents of the day tank or is drained to a safe location.

B.10 Diesel Fuel Storage and Transfer Areas.

B.10.1 Diesel fuel oil storage tanks should not be located inside buildings containing other nuclear safety–related equipment. If aboveground tanks are used, they should be located at least 50 ft (15.2 m) from any building; if within 50 ft (15.2 m), they should be separated from the building by a fire barrier having a minimum 3-hour rating. Potential oil spills should be confined or directed away from buildings containing safety-related equipment.

B.10.1.1 Underground tanks are acceptable outside or under buildings. *(See NFPA 30 for additional guidance.)*

B.10.2 Aboveground tanks should be provided with automatic fire suppression systems.

B.11 Nuclear Safety–Related Pump Rooms. These rooms should be protected by fire detection systems. Automatic fire suppression systems should be provided unless the fire hazards analysis determines that fire suppression is not required. Fire hose stations and fire extinguishers should be readily accessible.

B.12 New Fuel Area.

B.12.1 Fire extinguishers should be located within the new fuel area. Fire hose stations should be located as determined by the fire hazards analysis to facilitate access and use for fire-fighting operations. Fire detection systems should be provided. Combustible material should be limited to the minimum necessary for operation in the new fuel area.

B.12.2 The storage configuration of new fuel should always be maintained to preclude criticality for any water density that could occur during fire water application.

B.13 Spent-Fuel Pool Area. Protection for the spent-fuel pool area should be provided by fire hose stations and fire extinguishers. Fire detection should be provided in the area.

B.14 Rad Waste and Decontamination Areas. Fire barriers, fire detection, and automatic fire suppression should be provided as determined by the fire hazards analysis. Manual ventilation control to assist in smoke removal should be provided if necessary for manual fire fighting.

B.15 Safety-Related Water Tanks. Storage tanks that supply water for fire-safe shutdown should be protected from the effects of an exposure fire. Combustible materials should not be stored next to these tanks.

B.16 Record-Storage Areas. Record-storage areas should be located and protected in accordance with NFPA 232. Record-

storage areas should not be located in safety-related areas and should be separated from safety-related areas by fire barriers having a minimum 3-hour rating.

B.17 Cooling Towers.

B.17.1 Cooling towers should be of noncombustible or limited-combustible construction and located such that a fire in the cooling tower will not adversely affect safety-related systems or equipment. Cooling towers should be of noncombustible construction where the basin is used as the ultimate heat sink.

B.17.2 Cooling towers of combustible construction should be protected by automatic sprinklers or water spray systems in accordance with NFPA 214 and should be located so that they do not affect safety-related systems or equipment in the event of a fire.

B.18 Acetylene-Oxygen Fuel Gases. Gas cylinder storage locations or the fire protection systems that serve those safety-related areas should not be in areas that contain or expose safety-related equipment.

B.19 Storage Areas for Ion Exchange Resins. Unused ion exchange resins should not be stored in areas that contain or expose safety-related systems or equipment.

B.20 Storage Areas for Hazardous Chemicals. Hazardous chemicals should not be stored in areas that contain or expose safety-related systems or equipment.

B.21 Warehouses. Automatic sprinkler protection should be provided for warehouses that contain high-value equipment or combustible materials.

B.22 Fire Pump Room/House. Rooms housing diesel-driven fire pumps should be protected by automatic sprinkler, water spray, or foam-water sprinkler systems. If sprinkler and water spray systems are provided for fire pump houses, they should be designed for a minimum density of 0.25 gpm/ft^2 (10.19 L/min · m^2) over the entire fire area.

B.23 Transformers.

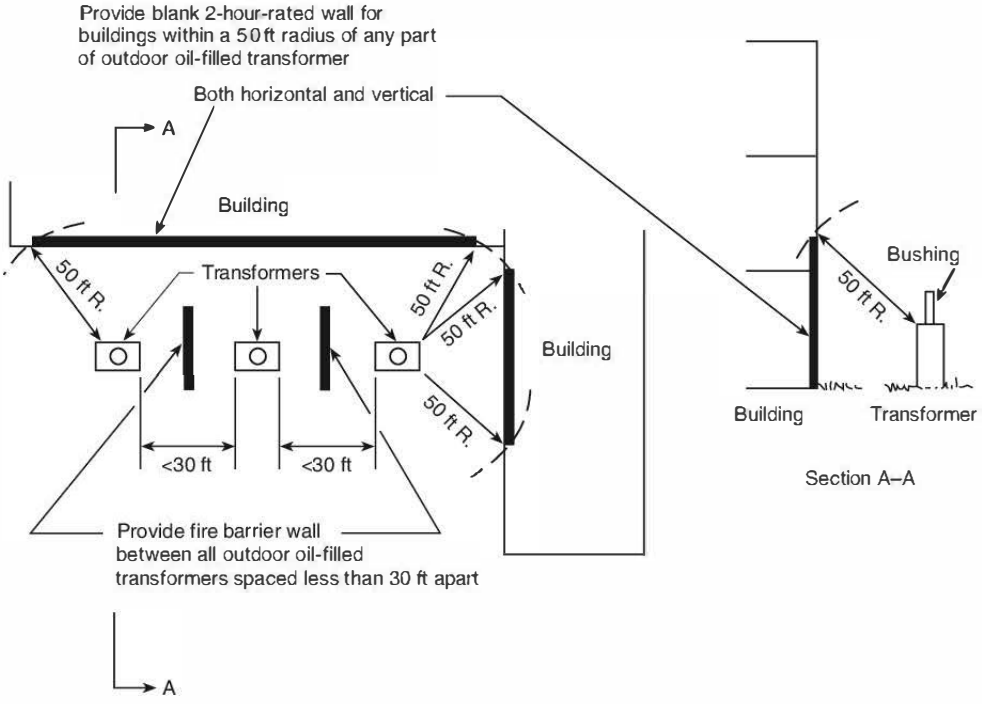
B.23.1 Buildings should be protected from exposure fires involving oil-filled transformers by locating the transformer casing, conservator tank, and cooling radiators at least 50 ft (15.2 m) from buildings, by providing a minimum 2-hour fire barrier between transformers and exposed buildings, as shown in Figure B.23.1(a) and Figure B.23.1(b), or by complying with Table B.23.1. A minimum 1-hour fire barrier or a distance of 30 ft (9.1 m) should be provided between adjacent transformers. Means should be provided to contain oil spills.

B.23.2 Oil-filled main, station service, and start-up transformers should be protected with automatic water spray systems in accordance with NFPA 15 or foam-water spray systems in accordance with NFPA 16.

B.23.3 Transformers installed inside fire areas containing safety-related systems or equipment should be of the dry type or insulated and cooled with noncombustible liquid.

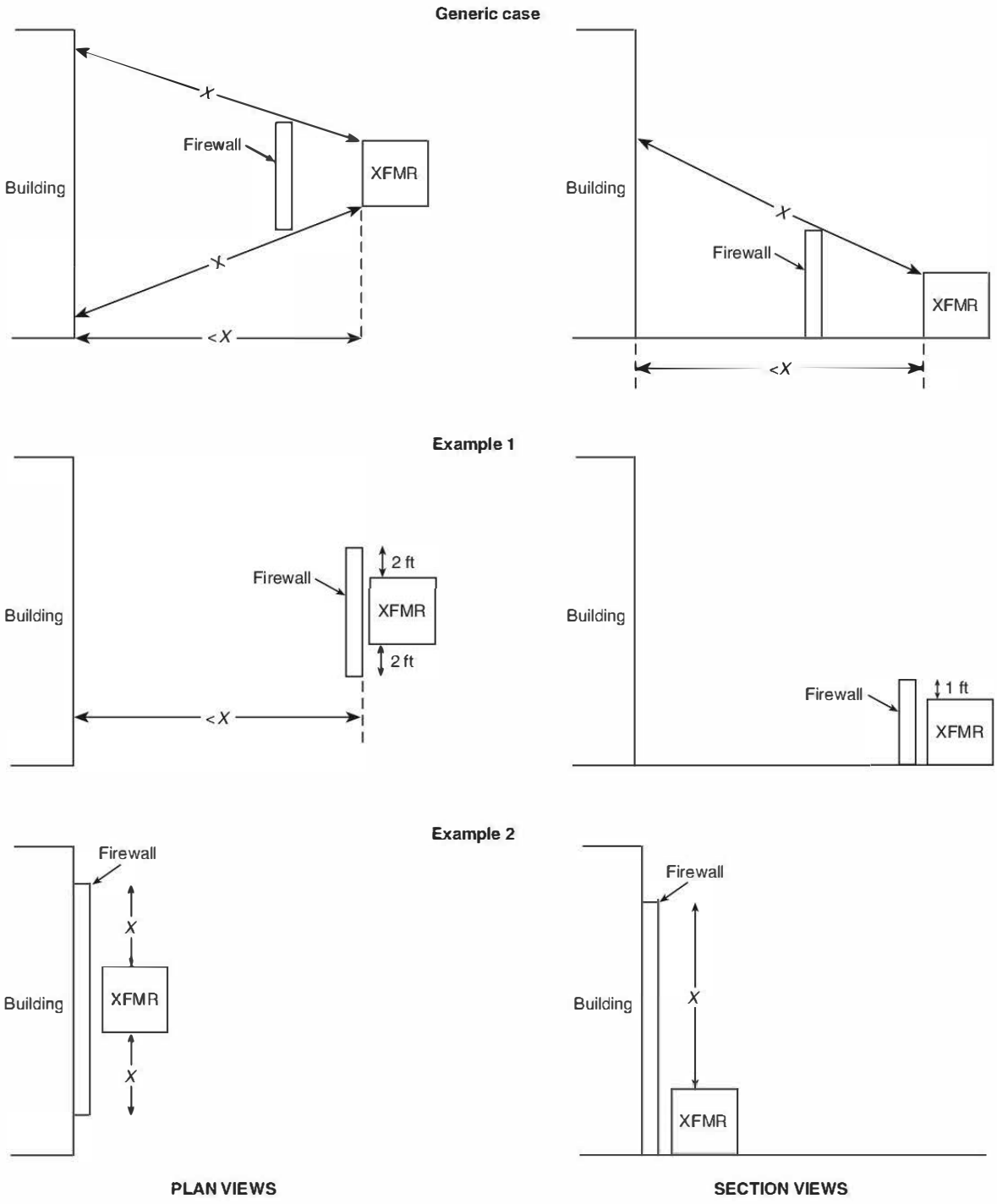
Table B.23.1 Transformer Spacing Separation Distances

Transformer Oil Capacity	Minimum (Line-of-Sight) Separation Without Firewall
Less than 5000 gal (18,925 L)	25 ft (7.6 m)
Over 5000 gal (18,925 L)	50 ft (15.2 m)



For SI units: 1 ft = 0.3048 m.

FIGURE B.23.1(a) Transformer Spacing.



Notes:
(1) X= Minimum separation distance, from Table B.23.1.
(2) For SI units: 1 ft = 0.3048 m.

FIGURE B.23.1(b) Examples of Transformer Spacing.

B.23.4 Transformers filled with combustible fluid that are located indoors should be enclosed in a transformer vault *(see Article 450 of NFPA 70)*.

B.24 Auxiliary Boilers.

B.24.1 Auxiliary boilers, their fuel burning systems, combustion product removal systems, and related control equipment should be installed and operated in accordance with NFPA 85.

B.24.2 Oil-fired boilers or boilers using oil ignition within the main plant should be protected with automatic sprinkler, water spray, or foam-water sprinkler systems covering the boiler area. Sprinkler and water spray systems should be designed for a minimum density of 0.25 gpm/ft^2 (10.19 L/min · m^2) over the entire area.

B.25 Offices, Shops, and Storage Areas. Automatic sprinklers should be provided for storage rooms, offices, and shops containing combustible materials that present an exposure to surrounding areas that are critical to plant operation, and should be so located and protected that a fire or the effects of a fire, including smoke, will not adversely affect any safety-related systems or equipment.

B.26 Simulators. Simulators should be provided with a fixed automatic suppression system. Simulators and supporting equipment should be separated from other areas by a fire barrier with a minimum 1-hour rating.

B.27 Technical Support and Emergency Response Centers. Technical support centers should be separated from all other areas by fire barriers or separated from all other buildings by at least 50 ft (15.2 m), and they should be protected by an automatic fixed suppression system as required by the fire hazards analysis.

B.28 Intake Structures. Intake structures should be of noncombustible construction and should be provided with automatic sprinkler protection.

Annex C Informational References

C.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

C.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

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

NFPA 4, *Standard for Integrated Fire Protection and Life Safety System Testing*, 2018 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 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 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 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2018 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2020 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 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 92, *Standard for Smoke Control Systems*, 2018 edition.

NFPA *101®, Life Safety Code®*, 2018 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 232, *Standard for the Protection of Records*, 2017 edition.

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

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

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

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

NFPA 806, *Performance-Based Standard for Fire Protection for Advanced Nuclear Reactor Electric Generating Plants Change Process*, 2020 edition.

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

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

C.1.2 Other Publications.

C.1.2.1 ANS Publications. American Nuclear Society, 555 North Kensington Avenue, La Grange Park, IL 60526.

ANS 59.4, *Generic Requirements for Light Water Nuclear Power Plant Fire Protection*, 1979 edition.

C.1.2.2 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

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

C.1.2.3 EPRI Publications. Electric Power Research Institute, 3420 Hillview Avenue, Palo Alto, CA 94304.

EPRI Research Report 1843-2, "Turbine Generator Fire Protection by Sprinkler System," July 1985.

C.1.2.4 IEEE Publications. IEEE, Three Park Avenue, 17th Floor, New York, NY 10016-5997.

ANSI/IEEE C2, *National Electrical Safety Code®*, 2012 edition.

IEEE 484, *Recommended Practice for Installation Design and Installation of Large Lead Batteries for Generating Stations and Substations*, 2002 edition.

C.1.2.5 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401–0001.

Title 10, Code of Federal Regulations, Part 100, "Reactor Site Criteria."

NRC Generic Letter 88-20, Supplement 4, "Sandia Risk Scoping Items."

C.2 Informational References. The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.

C.2.1 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401–0001.

NRC Generic Letter 86-10, Supplement 1.

C.3 References for Extracts in Informational Sections.

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

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