

NFPA 804

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

2001 Edition



NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 804

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

2001 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 and acted on by the National Fire Protection Association, Inc., at its November Meeting held November 12–15, 2000, in Orlando, FL. It was issued by the Standards Council on January 13, 2001, with an effective date of February 9, 2001, and supersedes all previous editions.

This edition of NFPA 804 was approved as an American National Standard on February 9, 2001.

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 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 this 2001 edition. All the changes were in the definitions section to comply with the NFPA Glossary of Terms.

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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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Electric Generating Plants**

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

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

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

Chapter 1 Introduction

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 upon the principle of defense in depth.

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

1.3.1 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. Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency. The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.3.2 The specific requirements of this standard shall be permitted to be modified by the authority having jurisdiction to allow alternative arrangements that will secure as nearly as practical the level of fire protection intended by this document, but in no case shall the modification afford less fire protection than that which, in the judgment of the authority having jurisdiction, would be provided by compliance with the corresponding provisions contained in this standard.

1.3.3 Alternative fire protection methods accepted by the authority having jurisdiction shall be considered as conforming with this standard.

1.4 Definitions.

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

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

1.4.3* Approved. Acceptable to the authority having jurisdiction.

1.4.4* 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.

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

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

1.4.7 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).

1.4.8* Combustible. Capable of undergoing combustion.

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

1.4.10* 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.

1.4.11* 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.

1.4.12* 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.

1.4.13 Fire Barrier. A continuous vertical or horizontal construction assembly designed and constructed to limit the spread of heat and fire and to restrict the movement of smoke.

1.4.14* Fire Brigade. As used in this standard, refers to those on-site persons trained in plant fire-fighting operations.

1.4.15 Fire Door. A door assembly rated in accordance with NFPA 252, *Standard Methods of Fire Tests of Door Assemblies*, and installed in accordance with NFPA 80, *Standard for Fire Doors and Fire Windows*.

1.4.16 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.

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

1.4.18 Fire Protection. Methods of providing fire detection, control, and extinguishment.

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

1.4.20* Fire-Rated Cables. Cables with an hourly fire resistance rating based on maintaining functionality when exposed to fire tests in NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*.

1.4.21 Fire-Rated Internal Conduit Seal. A conduit seal that is a tested and approved hourly rated fire seal in accordance with ASTM E 814, *Fire Tests of Through-Penetration Fire Stops*.

1.4.22 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.

1.4.23 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 component under consideration.

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

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

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

1.4.27 Flame Spread Rating. A relative measurement of the surface burning characteristics of building materials when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*.

1.4.28 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).

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

1.4.30 High Impedance Faults. Fire-induced faults on non-safe shutdown essential 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.

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

1.4.32 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.

1.4.33 Limited-Combustible. A building construction material not complying with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg), where tested in accordance with NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, and complies with (a) or (b) below. Materials subject to increase in combustibility or flame spread index beyond the limits herein established through the effects of age, moisture, or other atmospheric condition shall be considered combustible. (a) Materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of $\frac{1}{8}$ in. (3.2 mm) that has a flame spread index not greater than 50. (b) Materials, in the form and

thickness used, other than as described in (a), having neither a flame spread index greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion.

1.4.34* 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.

1.4.35 Noncombustible. Not capable of supporting combustion.

1.4.36 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.

1.4.37* 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.

1.4.38* 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.

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

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

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

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

1.4.43* 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.

1.4.44 Shall. Indicates a mandatory requirement.

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

1.4.46* 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.

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

Chapter 2 Fire Protection Program

2.1* General. All elements of the site fire protection program shall be reviewed every two years, and updated as necessary.

Exception: Other review frequencies are acceptable where specified in site administrative procedures and approved by the authority having jurisdiction.

2.2 Management Policy Direction and Responsibility.

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

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

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

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

2.3 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) A procedure 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, Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*)
- (6) A fire prevention surveillance plan (*see NFPA 601, Standard for Security Service in Fire Loss Prevention*)
- (7) A fire reporting procedure, including investigation requirements and corrective action requirements

2.4* Fire Hazards Analysis. A documented fire hazards analysis shall be made for each site. The analysis shall document all of the following:

- (1) The physical construction and layout of the buildings and equipment, including fire areas and the fire ratings of area boundaries
- (2)* An inventory of the principal combustibles within each fire subdivision
- (3) A description of the fire protection equipment, including alarm systems and manual and automatic extinguishing systems
- (4) A description of any equipment necessary to ensure a safe shutdown, including cabling and piping between equipment, and the location of such equipment
- (5) An analysis of the postulated fire in each fire area, including its effect on safe shutdown equipment, assuming automatic and manual fire protection equipment does not function
- (6) An 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) An analysis of the potential effects of other hazards, such as earthquakes, storms, and floods, on fire protection
- (8) An 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) An analysis of the postfire recovery potential
- (10) An analysis for the protection of nuclear-safety-related systems and components from the inadvertent actuation or breaks in a fire protection system
- (11) An analysis of the smoke control system, and the impact smoke can have on nuclear safety and operation for each fire area
- (12) An analysis of the emergency planning and coordination requirements necessary for effective loss control. This shall include any necessary compensatory measures to compensate for the failure or inoperability of any active or passive fire protection system or feature.

2.5 Procedures. A formal procedure system for all actions pertaining to the fire protection program shall be established. This shall include 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

2.6 Quality Assurance.

2.6.1 A quality assurance program shall be established in accordance with ASME NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities*, for all of these 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

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

2.7 Fire Emergency Plan. A written fire emergency plan shall be established. 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) A 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

2.8 Fire Brigade. A plant fire brigade shall be established as indicated in Chapter 4.

Chapter 3 Fire Prevention and Administrative Controls

3.1* General.

3.2 Plant Inspections.

3.2.1 The owner or his or her 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.

3.2.2 Inspections of the plant shall be conducted in accordance with NFPA 601, *Standard for Security Services in Fire Loss Prevention*. A prepared checklist shall be used for the inspection. 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. The results of each inspection shall be documented and retained for two years.

Exception: For those plant areas inaccessible for periods greater than two years, the most recent inspection shall be retained.

3.3 Control of Combustible Materials.

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

3.3.1.1* 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.

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

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

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

3.3.1.5 The storage and use of hydrogen shall be in accordance with NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, and NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites*.

3.3.1.6 The temporary use of wood shall be minimized. Plant administrative procedures shall specify that if wood must be used in the power block, it shall be listed pressure-impregnated fire-retardant lumber.

3.3.2 Housekeeping.

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

3.3.2.2 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.

3.3.3 Transient Combustible Loading.

3.3.3.1* Plant administrative procedures shall require that the total fire loads, including temporary and permanent combustible loading, will not exceed those quantities established for extinguishment by permanently installed fire protection systems and equipment.

Exception: Where limits are temporarily exceeded, the plant fire protection manager shall assure that appropriate fire protection measures are provided.

3.3.3.2 The fire protection manager or his or her designated representative shall conduct weekly walk-through inspections to ensure implementation of required controls. During major maintenance operations, the frequency of these walk-throughs shall be increased to daily. The results of these inspections shall be documented and the documentation retained for a minimum of two years.

3.3.3.3 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. Extra equipment shall then be returned to its proper location. The results of this inspection shall be documented and retained for two years.

3.3.3.4* Only noncombustible panels or flame-retardant tarpaulins or approved materials of equivalent fire-retardant characteristics shall be used. Any other fabrics or plastic films used shall be certified to conform to the large-scale fire test described in NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*.

3.3.4 Flammable and Combustible Liquids.

3.3.4.1 Flammable and combustible liquid storage and use shall be in accordance with NFPA 30, *Flammable and Combustible Liquids Code*. Where oil-burning equipment, stationary combustion engines, or gas turbines are used, they shall be installed and used in accordance with NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, or NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, as appropriate.

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

3.3.4.3 Hydraulic systems shall use only listed fire-resistant hydraulic fluids.

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

3.3.4.4 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

3.4 Control of Ignition Sources. Plant administrative procedures shall require an in-plant review and prior approval of all work plans to assess potential fire hazard situations. Where such conditions are determined to exist, special precautions shall be taken to define appropriate conditions under which the work is authorized.

3.4.1 Hot Work.

3.4.1.1 The owner or his or her designated manager shall develop, implement, and update as necessary a welding and cutting safety procedure using NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, and NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*, as a guide.

3.4.1.2 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.

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

- (1) An inspection has determined that hot work can be safely conducted at the desired location.
- (2) Combustibles have been moved away or safely 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.

3.4.1.4 All cracks or openings in floors shall be safely covered or closed.

3.4.2 Smoking.

3.4.2.1 Smoking shall be prohibited at or in the vicinity of hazardous operations or combustible and flammable materials. "No Smoking" signs shall be posted in these areas.

3.4.2.2 Smoking shall be permitted only in designated and supervised safe areas of the plant. Where smoking is permitted, safe receptacles shall be provided for smoking materials.

3.4.3 Temporary Electrical Wiring. The ignition of flammable materials shall be minimized by requiring that all temporary electrical wiring

- (1) Be kept to a minimum
- (2) Be suitable for the location
- (3) Be installed and maintained in accordance with NFPA 70, *National Electrical Code*[®], or ANSI 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

3.4.4 Temporary Heating Appliances.

3.4.4.1 Only safely installed, approved heating devices shall be used in all locations. 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, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances* (connectors and solid fuel); NFPA 54, *National Fuel Gas Code* (fuel gas appliances); and NFPA 31, *Standard for the Installation of Oil-Burning Equipment* (liquid fuel appliances).

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

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

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

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

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

3.5 Temporary Structures.

3.5.1 Exterior Buildings.

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

3.5.1.2 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).

Exception: 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 3.5.1.2.

Table 3.5.1.2 Minimum Separation Distances

Exposed Building Fire Barrier Rating	Minimum Distance Where Exposing Building Is Without Protection		Minimum Distance Where Exposing Building Has Automatic Sprinklers	
	ft	m	ft	m
3 hr	5	1.5	0	0
2 hr	10	3.0	5	1.5
1 hr	20	6.1	10	3.0
< 1 hr	30	9.1	15	4.6

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

3.5.2 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.

3.5.3 Interior Temporary Facilities.

3.5.3.1 All interior temporary structures shall be constructed of noncombustible, limited-combustible, or fire-retardant pressure-impregnated wood. 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. The structure shall be protected by an automatic fire suppression system if the structure is constructed of fire-retardant pressure-impregnated wood.

3.5.3.2 This use of interior temporary coverings shall be limited to special conditions where interior temporary coverings are necessary. They shall be constructed of approved fire-retardant tarpaulins.

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

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

3.6 Impairments.

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

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

3.6.3* Appropriate post-maintenance testing shall be performed on equipment that was impaired to ensure that the system will function properly. 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.

3.7 Testing and Maintenance.

3.7.1 Upon installation, all new fire protection systems and passive fire protection features shall be preoperationally inspected and tested in accordance with applicable NFPA standards. Where appropriate test standards do not exist, inspections and test procedures described in the purchase and design specification shall be followed.

3.7.2* 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.

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

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

Chapter 4 Manual Fire Fighting

4.1 Prefire Plans.

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

4.1.2* The 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.

4.1.3 Prefire plans shall be reviewed and, if necessary, updated at least every two years.

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

4.2* On-Site Fire-Fighting Capability.

4.2.1 General.

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

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

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

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

4.2.2 Fire Fighter Qualifications and Requirements.

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

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

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

4.2.3 Each fire brigade member shall meet training qualifications as specified in Section 4.3.

4.3 Training and Drills.

4.3.1 Plant Fire Brigade Training.

4.3.1.1 Plant fire brigade members shall receive training consistent with the requirements contained in NFPA 600, *Standard on Industrial Fire Brigades*, or NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, as appropriate.

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

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

4.3.1.4 Written records that include, but are not limited to, initial fire brigade classroom and hands-on training, refresher training, special training schools attended, drill attendance records, and leadership training for fire brigades shall be maintained for each fire brigade member.

4.3.2 Drills.

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

4.3.2.2 Fire brigade drills shall be developed to test and challenge fire brigade response including brigade performance as a team, proper use of equipment, effective use of pre-fire plans, and coordination with other groups.

4.3.2.3 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.

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

4.3.2.5 A critique shall be held after each drill.

4.4 Fire-Fighting Equipment.

4.4.1* The plant fire brigade shall be provided with equipment that will enable them to adequately perform their assigned tasks.

4.4.2 Fire brigade equipment shall be tested and maintained. Written records shall be retained for review.

4.5 Off-Site Fire Department Interface.

4.5.1 Mutual Aid Agreement.

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

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

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

4.5.2 Site-Specific Training.

4.5.2.1 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.

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

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

4.5.3 Security and Health Physics.

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

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

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

4.7 Fire-Fighting Access.

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

4.7.2 Prefire plans shall identify those areas of the plant that are locked and have limited access for either security or radiological control reasons. Provisions shall be made to allow access to these areas. If necessary, this shall include having security and health physics personnel respond to the fire area along with the fire brigade. Health physics personnel shall confer with the fire brigade leader to determine the safest method of access to any radiologically controlled area.

4.8 Radiation Shielding.

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

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

4.9* 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 6.4.*)

Chapter 5 Nuclear Reactor Safety Considerations

5.1* General.

5.2 Fire Hazards and Safe Shutdown Analysis (FSSA). A fire safe shutdown analysis (FSSA) shall be prepared and maintained for the operating life of the reactor. The FSSA 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

5.2.1 Fire Hazards Analysis. The fire hazards analysis shall include the criteria indicated in Section 2.4.

5.2.2 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. The analysis shall include as a minimum the requirements of this section.

5.2.2.1 A safe shutdown system available/unavailable calculation or table shall be prepared and maintained for each fire area. This document shall identify all safe shutdown equipment that is operable or inoperable due to the effects of a fire in that fire area. This document shall demonstrate compliance with the requirements of Sections 5.3 and 5.4.

5.2.2.2* 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 those plant features necessary to realize these conditions, including auxiliary and support features.

5.2.3 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.

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

5.2.3.2* 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.

5.2.3.3 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.

5.3 Design Basis Events and Requirements.

5.3.1 Fire.

5.3.1.1 Only one fire is assumed to occur at a given time. For the purpose of a safe shutdown analysis, damage shall be assumed to occur immediately.

5.3.1.2* 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 worst case.

5.3.1.3* A fire shall not be assumed to impair safe shutdown capability inside primary containment or annulus areas.

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

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

5.3.1.6 Plant accidents or severe natural phenomena shall not be assumed to occur concurrently with a postulated fire.

Exception: For seismic/fire interaction, see 5.3.2.

5.3.1.7 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.

5.3.1.8 Fire safe shutdown components shall be capable of performing all of 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 achieve and maintain cold shutdown conditions
- (4) Providing support functions such as process cooling, lubrication, and so forth, necessary to permit operation of the FSSD components
- (5) Providing direct readings of the process variables necessary to perform and control the FSSD functions

5.3.1.9 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).

5.3.1.10 Spurious Signals.

5.3.1.10.1 An evaluation of spurious signals shall be performed based on these assumptions:

- (1) All potential spurious 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 fire-induced cable damage shall determine if any of the following cable failure modes are possible:
 - a. *Hot Short.* 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. *Open Circuit.* The cable failure results in the loss of electrical continuity.
 - c. *Shorts to Ground.* Cable conductors short to grounded structures.
 - d. *Short Circuit.* Individual conductors within multi-conductor cable short to each other.

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

5.3.1.11 Fire-Induced Spurious Actuation. The following postulates shall be used when analyzing fire-induced spurious actuation of equipment.

5.3.1.11.1 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.

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

5.3.1.11.3 Separate conditions shall be analyzed concurrent with the spurious actuation(s) or signal addressed in 5.3.1.10.1 and 5.3.1.10.2.

5.3.1.11.4 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 worst case.

5.3.1.11.5 All potential spurious signals shall be analyzed. However, only one spurious signal shall be postulated to occur at a time for purposes of analysis, except for high-low pressure interface valves.

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

5.3.1.13 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.

5.3.1.14* All associated circuits of concern shall be isolated from FSSD circuits by coordinated circuit breakers or fuses.

5.3.1.15* Circuits Associated by Common Enclosure.

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

5.3.1.15.2 The overcurrent protection devices shall be located outside of the fire area containing the common enclosure.

5.3.1.16 High Impedance Faults.

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

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

5.3.2* Seismic/Fire Interaction.

5.3.2.1 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.

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

5.3.2.3 The assessment shall be used to evaluate the level of safety of the plant. This assessment shall not be used to reduce the overall plant fire protection design basis.

5.4 Separation Criteria.

5.4.1 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.

5.4.2 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.

5.4.3 Redundant cables, equipment, components, and associated circuits of nuclear-safety-related or safe shutdown systems shall be located in separate fire areas. The fire barrier forming these fire areas shall have a 3-hour fire rating and automatic area-wide detection shall be installed throughout these fire areas. Structural steel forming a part of or supporting such fire barriers shall be protected to provide fire resistance equivalent to that of the barrier.

Exception No. 1: Where redundant system separation inside containment cannot be achieved, other measures shall be permitted in accordance with Section 5.6 to prevent a fire from causing the loss of function of nuclear-safety-related or safe shutdown systems.

Exception No. 2: Redundant cables, equipment, components, and associated circuits of nuclear-safety-related or safe shutdown systems shall be located in separate fire areas. The fire barriers forming these fire areas shall have a minimum fire-resistive rating of 1 hour, and automatic area-wide detection and suppression shall be installed throughout these fire areas. Structural steel forming a part of or supporting such fire barriers shall be protected to provide fire resistance equivalent to that of the barrier.

5.4.4 Fire areas separated by minimum 3-hour fire 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.

5.4.5 Within 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. Measures that shall be taken to reduce the effects of a postulated fire in a given fire area include limiting the amount of combustible materials (*see Section 3.3*), providing fire-rated barriers between major components and equipment to limit fire spread within a fire area (*see Section 6.1*), or installing fire detection (*see Section 7.8*) and fixed suppression systems (*see Section 7.6*).

5.5 Manual Actions.

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

5.5.2 Operator Actions.

5.5.2.1 Operator actions necessary to achieve FSSD of the reactor shall be kept to a minimum.

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

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

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

5.5.2.5 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.

5.5.2.6 Postfire shutdown and recovery plans shall be included in the station emergency preparedness plan. Drills and operator requalification training shall ensure that operations personnel are familiar with and can accomplish the necessary actions.

5.5.3 Operator Access and Equipment Operation.

5.5.3.1 Operator Access.

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

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

5.5.3.1.3 Emergency lighting shall be provided for the access routes and the remote shutdown location (*see Section 6.6*).

5.5.3.2 Equipment Operation.

5.5.3.2.1* Operator safety shall not be threatened by fire conditions while implementing FSSD of the reactor.

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

5.5.3.2.3 Operators (e.g., handwheels of valves that require manual manipulation for FSSD) shall be readily accessible. 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. The platform shall be of sufficient size to allow the operator to safely perform the manual action.

5.6 Alternative Shutdown Capability.

5.6.1 Alternative shutdown capability provided for a specific fire area shall include achieving and maintaining subcritical reactivity conditions in the reactor, maintaining the reactor coolant inventory, achieving safe shutdown, and maintaining safe shutdown following the fire event.

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

5.6.3 Performance goals for reactor shutdown functions shall be the same as those required by 5.3.1.8.

5.6.4 The safe shutdown circuits for each fire area 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. 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 6 General Plant Design

6.1 Plant Arrangement.

6.1.1 Building Separation.

6.1.1.1 In multi-unit 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.

6.1.1.2 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.

Exception: 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).

6.1.2 Fire Areas. 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. In addition, the subdivision into fire areas shall allow adequate access for manual fire suppression activities.

6.1.2.1 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

6.1.2.2 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. Openings in such barriers shall be protected with listed automatic or self-closing fire doors having a fire protection rating of at least 1¹/₂ hours.

6.1.3 Openings in Fire Barriers.

6.1.3.1 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.

Exception: The use of assemblies that are not listed or approved due to nuclear safety or security requirements shall be demonstrated to be equivalent.

6.1.3.2 Fire door assemblies, fire dampers, and fire shutters used in 2-hour-rated fire barriers shall be listed as not less than

1¹/₂ hour rated and shall meet the requirements of NFPA 80, *Standard for Fire Doors and Fire Windows*, for fire door requirements and NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, for fire damper requirements.

Exception: Where approved full-scale fire tests indicate that opening protection is not necessary, opening protection shall not be required.

6.1.3.2.1 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.

6.1.3.2.2 Cable openings, piping openings, and building joints shall be provided with fire-rated penetration seals. The sealing material shall be of limited-combustible or noncombustible material and shall meet the requirements of ASTM E 814, *Fire Tests of Through-Penetration Fire Stops*, or UL 1479, *Standard for Safety Fire Tests of Through-Penetration Firestops*.

6.1.3.2.3 Internal Conduit Seals. All conduits shall be sealed at the barrier with a fire-rated seal, if accessible. Alternatively, internally sealing with a fire-rated seal at the first break in the conduit on both sides of the barrier shall be acceptable. For the above configuration, the fire rating of the internal conduit seal shall be equivalent to the rating of the fire barrier being penetrated.

Exception: Where approved full-scale fire tests indicate that internal conduit seals are not necessary, internal conduit seals are not required.

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

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

6.1.3.3 Design features that provide for monitoring and control of fire doors to assure fire door operability and fire barrier integrity shall be provided.

Exception: Administrative procedures instead of design features shall be permitted.

6.2 Life Safety.

6.2.1* NFPA 101[®], *Life Safety Code*[®], shall be the standard for life safety from fire in the design and operation of the ALWR, except where modified by this standard.

6.2.2* 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, *Life Safety Code*.

6.2.3 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 upon NFPA 101, *Life Safety Code*.

6.2.4 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, *Life Safety Code*.

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

6.2.6 Warehouses and storage areas shall conform to the storage occupancy requirements in NFPA 101, *Life Safety Code*.

6.3 Building and Construction Materials.

6.3.1 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 E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*
- (3) NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials* (ASTM E 119, *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 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials* (ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials*)
- (6) NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*
- (7) NFPA 259, *Standard Test Method for Potential Heat of Building Materials*

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

6.3.2.1 Interior wall or ceiling finish classification shall be in accordance with NFPA 101, *Life Safety Code*, requirements for Class A material.

6.3.2.2 Interior floor finish classification shall be in accordance with NFPA 101, *Life Safety Code*, requirements for Class I interior floor finish.

6.3.3 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.

6.3.4 Electrical wiring above suspended ceilings shall be kept to a minimum. Electrical wiring shall be listed for plenum use, or armor-metal-jacketed, or routed in metallic conduits, or trays having both solid metallic bottoms and covers.

6.3.5 Roof coverings shall be Class A as determined by tests described in NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*.

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

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

6.3.7.1 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.

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

6.3.8 Bulk storage of flammable and combustible liquids shall not be permitted inside structures housing safety-related systems. As a minimum, the storage and use shall comply with the requirements of NFPA 30, *Flammable and Combustible Liquids Code*.

6.4* Ventilation.

6.4.1* The design, installation, and operation of ventilation systems necessary for normal and emergency operation of the

plant shall be in accordance with NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*.

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

6.4.3 Smoke removal shall be provided for nuclear-safety-related areas of the plant. Equipment shall be suitable for removing smoke without damage to equipment. The release to the environment of smoke containing radioactive materials shall be monitored in accordance with emergency plans.

Exception: For those plants provided with complete automatic sprinkler protection, fixed ventilation systems for the removal of smoke is not required.

6.4.3.1 Smoke and heat removal systems shall be provided for other fire areas based upon the fire hazards analysis.

Exception: For those plants provided with complete automatic sprinkler protection, fixed ventilation systems for the removal of smoke is not required.

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

6.4.3.3* 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.

6.4.4 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.

6.4.5 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.

6.4.6 The fresh air supply intakes to plant areas shall be located remote from the exhaust air outlets and smoke vents of other fire areas to minimize the possibility of contaminating the air intake with the products of combustion.

6.4.7 Enclosed stairwells shall be designed to minimize smoke infiltration during a fire.

6.4.8 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.

6.4.9 Duct Systems.

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

6.4.9.2 Interconnections of individual fire areas via the ventilation system shall be kept to a minimum.

6.4.9.3 Fire dampers shall be installed in accordance with NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*. Consideration shall be given to the velocity in the duct.

Exception No. 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 can be omitted from the fire barrier.

*Exception No. 2:** As an alternative to fire dampers, the duct system can be enclosed or constructed to provide the required fire barrier through adjacent areas. (Refer to Figure A.6.4.9.3 Exception No. 2.)

6.4.9.4 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. Where ventilation ducts penetrate required 3-hour fire barriers, approved fire dampers having a fire protection rating of 3 hours shall be installed.

6.4.9.5 Fire dampers shall be equipped for automatic closure by thermal release elements. The fire damper shall be mounted directly into the separating wall or the duct shall be protected between the wall and the damper according to the fire resistance of the separating wall structure.

6.4.9.6 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.

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

6.4.10 Filters.

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

6.4.10.2 In order to decrease the fire hazard of these filters and of oil-bath-type filters, only approved fire-resistive adhesives and oils with the Cleveland open-cup flash point (ASTM D 92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup*) equal to or greater than 464°F (240°C) and that do not produce appreciable smoke shall be used.

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

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

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

6.5 Drainage.

6.5.1* 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.

6.5.2 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

6.5.3 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, credible environmental factors such as rain and snow
- (5) Where automatic suppression is not provided throughout, the volume shall be based on a manual fire-fighting flow rate of 500 gal/min (1892.5 L/min) for a duration of 30 minutes, unless the fire hazards analysis demonstrates a different flow rate and duration

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

6.5.5 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.

6.5.6 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.

6.5.6.1 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.

6.5.6.2 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.

6.5.7 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.

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

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

6.6 Emergency Lighting.

6.6.1 Emergency lighting units shall provide adequate lighting levels. The lighting units shall be sized to provide a duration of operation that will adequately illuminate the egress and access routes to areas containing safe shutdown equipment and the equipment operation until normal or emergency plant lighting can be re-established.

6.6.2 The illumination of means of egress shall be in accordance with NFPA 101, *Life Safety Code*. The illumination shall include emergency lighting and marking of the means of egress.

6.6.3 The floor of the means of egress and the safe shutdown operations shall be illuminated at all points including angles,

intersections of corridors, passageways, stairways, landings of stairways, exit doors, safe shutdown equipment, and access and egress routes to safe shutdown equipment to values of not less than 1 footcandle measured at the floor and at safe shutdown equipment.

6.6.4 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.

6.6.5 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.

6.7 Lightning Protection. The plant shall be provided with a lightning protection system in accordance with NFPA 780, *Standard for the Installation of Lightning Protection Systems*.

6.8 Electrical Cabling.

6.8.1 As a minimum, combustible 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*. Meeting the requirements of IEEE 383 shall not eliminate the need for protection as specified in this standard and the fire hazards analysis.

6.8.2 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*.

6.8.3 Group cabling shall be routed away from exposure hazards or protected as specified in this standard. Specifically, group cabling shall not be routed near sources of ignition or flammable and combustible liquid hazards.

6.8.4 Cable raceways shall be used only for cables.

6.8.5 Only metal shall be used for cable trays.

6.8.6 Only metallic tubing shall be used for conduit.

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

6.8.6.1 Thin-wall metallic tubing shall not be used.

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

6.8.6.3 Other raceways shall be made of noncombustible materials.

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

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

6.10 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, *National Electrical Code*, or ANSI C2, *National Electrical Safety Code*, as applicable.

6.11 Communications.

6.11.1 The plant-approved voice/alarm communication system in accordance with NFPA 72, *National Fire Alarm Code*[®], shall

be available on a priority basis for fire announcements, directing plant fire brigade, and fire evacuation announcements.

6.11.2* A portable radio communication system shall be provided for use by the fire brigade and other operation personnel required to achieve safe shutdown.

6.11.3 The radio communication system shall not interfere with the communication capabilities of the plant security force.

6.11.4 The impact of fire damage on the communication systems shall be considered when installing fixed repeaters to permit the use of portable radios. Repeaters shall be located such that a fire-induced failure of the repeater will not also cause failure of the other communication systems relied upon for safe shutdown.

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

6.11.6 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 7 General Fire Protection Systems and Equipment

7.1 General.

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

7.1.2* All fire protection systems, equipment, and installations shall be dedicated to fire protection purposes.

Exception No. 1: Except when in accordance with 7.4.9.

Exception No. 2: Fire protection systems shall be permitted to be used to provide redundant backup to nuclear-safety systems provided the fire protection systems meet the design basis requirements of the nuclear-safety systems. Fire protection systems used in this manner shall be designed to handle both functions.

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

7.2 Water Supply.

7.2.1* 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). This 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, NFPA 13, *Standard for the Installation of Sprinkler Systems*, or NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*. The fire water supply shall be capable of delivering this design demand with the hydraulically least demanding portion of fire main loop out of service.

7.2.2* Two 100 percent [minimum of 300,000 gal (1,135,500 L) each] system capacity tanks shall be installed. The tanks shall be interconnected such that fire pumps can take suction from either or both. A failure in one tank or its piping shall not cause both tanks to drain. The tanks shall be designed in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection*.

Exception: Refill times for filling the water tanks do not apply.

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

7.2.4 Fire Pumps.

7.2.4.1 Fire pumps shall meet the requirements of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, and shall be automatic starting.

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

7.2.4.3 Individual fire pump connections to the yard fire main loop shall be separated with sectionalizing valves between connections. 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. The fuel for the diesel fire pump(s) shall be separated so that it does not provide a fire source exposing safety-related equipment.

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

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

7.3 Valve Supervision. All fire protection water supply and system control valves shall be under a periodic inspection program (see *Chapter 3*) 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. Keys shall be made available only to authorized personnel.
- (3) Sealing valves in their normal positions and weekly valve inspections. This option shall be utilized only where valves are located within fenced areas or under the direct control of the property owner.

7.4 Yard Mains, Hydrants, and Building Standpipes.

7.4.1* The underground yard fire main loop shall be installed to furnish anticipated water requirements. The type of pipe and water treatment shall be design considerations, with tuberculation as one of the parameters. Means for inspecting and flushing the systems shall be provided.

7.4.2 Approved visually indicating sectional control valves such as post-indicator 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.

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

7.4.4* Sectional control valves shall permit maintaining independence of the individual loop around each unit. For such installations, common water supplies shall also be permitted to be utilized. For multiple-reactor sites with widely separated plants [approaching 1 mi. (1.6 km) or more], separate yard fire main loops shall be used.

7.4.5 Outside manual hose installation shall be sufficient to provide an effective hose stream to any on-site location. Hydrants with individual hose gate valves shall be installed approximately every 250 ft (76 m) apart on the yard main system. A hose house equipped with hose and combination nozzle and other auxiliary equipment specified in NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, shall be provided at intervals of not more than 1000 ft (305 m) along the yard main system.

Exception: Mobile means of providing hose and associated equipment, such as hose carts or trucks, shall be permitted in lieu of hose houses. Where provided, such mobile equipment shall be equivalent to the equipment supplied by three hose houses.

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

7.4.7 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 backup fire suppression systems. 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 ANSI B31.1, *Code for 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. Where provided, such headers shall be considered an extension of the yard main system. Each sprinkler and standpipe system shall be equipped with an outside screw and yoke (OS&Y) gate valve or other approved shutoff valve.

7.4.8 For all power block buildings, Class III standpipe and hose systems shall be installed in accordance with NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems*. For all other buildings on site, the requirements for standpipe and hose systems shall be appropriate for the hazard being protected.

7.4.9* The proper type of hose nozzle to be supplied to each area shall be based on the fire hazards analysis. The usual combination spray/straight-stream nozzle shall not be used in areas where the straight stream can cause unacceptable damage. Approved, electrically safe fixed fog nozzles shall be provided at locations where high-voltage shock hazards exist. All hose nozzles shall have shutoff capability.

7.4.10 Seismic Fire Suppression Capabilities.

7.4.10.1* 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).

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

7.4.10.3 The system shall be designed to flow a minimum of one Class III standpipe station in accordance with NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems*.

7.4.10.4 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.

7.5 Portable Fire Extinguishers.

7.5.1 Portable and wheeled fire extinguishers shall be installed, inspected, maintained, and tested in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

Exception: 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, Standard on Portable Fire Extinguishers, or consideration shall be given to locating the extinguishers outside high radiation areas.

7.6 Fire Suppression Systems.

7.6.1 Automatic suppression systems shall be provided in all areas of the plant as required by the fire hazards analysis. Except as modified in this chapter, the following NFPA standards shall be used:

- (1) NFPA 11, *Standard for Low-Expansion Foam*
- (2) NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*
- (3) NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*
- (4) NFPA 13, *Standard for the Installation of Sprinkler Systems*
- (5) NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*
- (6) NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*
- (7) NFPA 17, *Standard for Dry Chemical Extinguishing Systems*
- (8) NFPA 214, *Standard on Water-Cooling Towers*
- (9) NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*

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

7.6.3 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 such as thermal shock, continued operability, water damage, overpressurization, cleanup, and so forth
- (3) Health hazards

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

7.7 Fire Alarm Systems.

7.7.1 Fire signaling systems shall be provided in all areas of the plant as required by the fire hazards analysis. The requirements of this chapter shall constitute the minimum acceptable protective signaling system functions when used in conjunction with NFPA 72, *National Fire Alarm Code*.

7.7.2* 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.

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

7.7.4* Audible signaling appliances shall produce a distinctive sound, used for no other purpose. Audible signaling devices shall be located and installed so that the alarm can be heard above ambient noise levels.

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

7.7.6 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, *National Fire Alarm Code*, and shall be routed outside the area to be protected.

7.7.7* Manual fire alarm boxes shall be installed as required by the fire hazards analysis. 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 clearly marked for that purpose. The manual release device circuits shall be routed outside the area protected by the fixed extinguishing system.

7.7.8 All signals shall be permanently recorded in accordance with NFPA 72, *National Fire Alarm Code*.

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

- (1) NFPA 72, *National Fire Alarm Code*
- (2) The design parameters required as a result of the fire hazards analysis of the plant area
- (3) The additional requirements of this standard

Chapter 8 Identification of and Protection Against Hazards

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

8.2 Primary and Secondary Containments.

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

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

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

8.2.1.3 A general area fire detection capability shall 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 shall be installed in accordance with NFPA 72, *National Fire Alarm Code*.

8.2.1.4 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 sufficient quantity and pressure other than the fire main loop if plant-specific features prevent extending the fire main supply inside containment.

Exception: 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.

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

8.2.1.6* 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. Leakage shall be collected and drained to a vented closed container that can hold the entire oil system inventory. Leakage points to be protected shall 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 shall be large enough to accommodate the largest potential oil leak.

8.2.2 Refueling and Maintenance.

8.2.2.1* Management procedures and controls necessary to ensure adequate fire protection for fire hazards introduced during maintenance and refueling shall be provided. Adequate backup fire suppression shall be provided so that total reliance is not placed on a single fire suppression system.

8.2.2.2 Adequate self-contained breathing apparatus shall be provided near the containment entrance for fire-fighting and damage control personnel. These units shall be independent of any breathing apparatus or air supply systems provided for general plant activities and shall be clearly marked as emergency equipment.

8.3 Control Room Complex.

8.3.1 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. 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. 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.

8.3.2 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

8.3.3 Portable Class A and Class C fire extinguishers shall be located in the control room. A fire hose station shall be installed immediately outside of the control room.

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

8.3.5 Smoke detectors shall 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 shall be provided with internal separation (noncombustible barriers) to limit the damage to one safety division.

8.3.6 Breathing apparatus for the control room operators shall be readily available.

8.3.7 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.

8.3.8 Venting of smoke produced by a fire in the control room by means of the normal ventilation system shall be permitted to be acceptable; however, provision shall be made to permit isolation of the recirculation portion of the normal ventilation system. Manually operated venting of the control room shall be available to the operators.

8.3.9 All cables that enter the control room shall terminate in the control room. No cabling shall be routed through the control room from one area to another. Cables in spaces underfloor and in above-ceiling spaces shall meet the separation criteria necessary for fire protection.

8.3.10 Air-handling functions shall be ducted separately from cable runs in such spaces (i.e., if cables are routed in underfloor or ceiling spaces, these spaces shall 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 ft² (0.09 m²) in cross-sectional area, shall have automatic fire suppression inside. 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.

8.4 Cable Concentrations.

8.4.1 Cable Spreading Room.

8.4.1.1 The cable spreading room shall have an automatic water-based suppression system. The location of sprinklers or spray nozzles shall consider cable tray arrangements to ensure adequate water coverage for areas that could present exposure fire hazards to the cable raceways. Automatic sprinkler systems

shall be designed for a density of 0.30 gpm/ft² (12.2 L/min·m²) over the most remote 2500 ft² (232.2 m²).

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

8.4.1.3 Cable spreading rooms shall 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

8.4.2 Cable Tunnels.

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

8.4.2.2 Suppression Systems.

8.4.2.2.1 Cable tunnels shall be provided with automatic fixed suppression systems. Automatic sprinkler systems shall be designed for a density of 0.30 gpm/ft² (12.2 L/min·m²) for the most remote 100 linear ft (30.5 m) of cable tunnel up to the most remote 2500 ft² (232.2 m²).

8.4.2.2.2 The location of sprinklers or spray nozzles shall 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.

8.4.2.2.3 Deluge sprinkler systems or deluge spray systems shall be zoned to limit the area of protection to that which the drainage system can handle with any two adjacent systems actuated. The systems shall be hydraulically designed with each zone calculated with the largest adjacent zone flowing.

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

8.4.2.4 Cable tunnels over 50 ft (15.2 m) long shall 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

8.4.3 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). 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. Automatic sprinkler protection and smoke detection shall be provided at the ceiling of the vertical shaft.

8.5 Plant Computer and Communication Rooms. Computer and communication rooms shall meet the applicable requirements of NFPA 75, *Standard for the Protection of Electronic Computer/Data Processing Equipment*.

8.6 Switchgear Rooms and Relay Rooms.

8.6.1* Smoke detection shall be provided and shall alarm in both the control room and locally. Cables entering the safety-related switchgear rooms shall terminate in the switchgear room. The safety-related switchgear rooms shall not be used for other purposes. Fire hose stations and portable fire extinguishers shall be readily available outside the area.

8.6.2 Equipment shall be located to facilitate fire fighting. Drains shall be provided to prevent water accumulation from damaging safety-related equipment. Remote manually actuated ventilation shall be provided for smoke removal when manual fire suppression is needed. (*See Section 6.4.*)

8.7 Battery Rooms.

8.7.1* Battery rooms shall be provided with ventilation to limit the concentration of hydrogen to 2 percent by volume. Loss of ventilation shall alarm in the control room.

8.7.2 Safety-related battery rooms shall be protected against fires and explosions. Battery rooms shall be separated from other areas of the plant by fire barriers having a 1-hour minimum rating. Direct current switchgear and inverters shall not be located in these battery rooms. Fire detection shall be provided. Fire hose stations and portable fire extinguishers shall be readily available outside the room.

8.8 Turbine Building.

8.8.1* The turbine building shall be separated from adjacent structures containing safety-related equipment by fire-resistive barriers having a minimum 3-hour rating. The fire barriers shall be designed so that the barrier will remain in place even in the event of a complete collapse of the turbine structure. 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. Smoke and heat removal systems shall be provided in accordance with 6.4.3.

Exception: For those plants provided with complete automatic sprinkler protection at the roof level, smoke and heat removal systems are not required.

8.8.2 Beneath Turbine Generator Operating Floor.

8.8.2.1* All areas beneath the turbine generator operating floor shall be protected by an automatic sprinkler or foam-water sprinkler system. The sprinkler system beneath the turbine generator shall take into consideration obstructions from structural members and piping and shall be designed to a minimum density of 0.30 gpm/ft² (12.2 L/min·m²) over a minimum application of 5000 ft² (464.5 m²).

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

8.8.2.3 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.

8.8.3* Turbine Generator Bearings.

8.8.3.1 Automatic fixed suppression systems shall be provided for all turbine generator and exciter bearings. If closed-head water spray systems utilizing directional nozzles in accordance

with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, are provided, bearing protection shall be provided for a minimum density of 0.30 gpm/ft² (12.2 L/min·m²) over the protected area.

8.8.3.2 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.

8.8.4 Lubricating oil lines above the turbine operating floor shall 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 shall be designed to a minimum density of 0.30 gpm/ft² (12.2 L/min·m²).

8.8.5 Lubricating oil reservoirs and handling equipment shall be protected in accordance with 8.8.2.1. If the lubricating oil reservoir is elevated, sprinkler protection shall be extended to protect the area beneath the reservoir.

8.8.6 If shaft-driven ventilation systems are not used, the area inside a directly connected exciter housing shall 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/ft² (12.2 L/min·m²) over the entire area shall be provided.

8.8.7* Clean or dirty oil storage areas shall be protected based on the fire risk evaluation. The designer shall consider, as a minimum, the installation of fixed automatic fire protection systems and the ventilation and drainage requirements in Chapter 6.

8.8.8 Hydrogen Systems.

8.8.8.1* General.

8.8.8.1.1* 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. Alternatively, vented guard piping shall be permitted to be used inside the building to protect runs of hydrogen piping.

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

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

8.8.8.1.4 The generator hydrogen dump valve and hydrogen detrainment equipment shall be arranged to vent directly to a safe outside location. The dump valve shall be remotely operable from the control room or from an area accessible during a machine fire.

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

8.8.8.2 Hydrogen Seal Oil Pumps.

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

8.8.8.2.2 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 gener-

ator to minimize the possibility of loss of both pumps as a result of a turbine generator fire.

8.8.8.2.3 Hydrogen seal oil units shall be protected in accordance with 8.8.2. Hydrogen seal oil units shall 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.

8.8.8.2.4 Curbing or drainage or both shall be provided for the hydrogen seal oil unit in accordance with Section 6.5.

8.8.8.3 Hydrogen in Safety-Related Areas.

8.8.8.3.1 Hydrogen lines in safety-related areas shall be either designed to seismic Class I requirements or sleeved such that the outer pipe is directly vented to the outside, or 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.

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

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

8.8.10* Lubricating Oil Systems.

8.8.10.1 Turbine lubricating oil reservoirs shall be provided with vapor extractors, which shall be vented to a safe outside location.

8.8.10.2 Curbing or drainage or both shall be provided for the turbine lubricating oil reservoir in accordance with Section 6.5.

8.8.10.3 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.

8.8.10.4* Piping design and installation shall 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) Route oil piping clear of or below steam piping or metal parts
- (4) Insulate with impervious lagging for steam piping or hot metal parts under or near oil piping or turbine bearing points

8.8.10.5 Cable for operation of the lube oil pumps shall be protected from fire exposure. Where feasible, electrical circuits to redundant pumps shall be run in buried conduit. 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).

8.9 Standby Emergency Diesel Generators and Combustion Turbines.

8.9.1 The installation and operation of standby emergency diesel generators and combustion turbines shall be in accordance with NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*.

Exception: Automatic shutdown and remote shutdown features, which shall be governed by nuclear-safety requirements.

8.9.2 Standby emergency diesel generators and combustion turbines located within main plant structures shall be protected by automatic sprinkler, water spray, or foam-water sprinkler systems. Sprinkler and water spray protection systems shall

be designed for a 0.25-gpm/ft² (10.19-L/min·m²) density over the entire area.

8.9.3 Fire detection shall be provided to alarm and announce in the control room and to alarm locally. Fire hose stations and portable fire extinguishers shall be readily available outside the area. Drainage for fire-fighting water and means for local manual venting of smoke shall be provided.

8.9.4 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.

8.10 Diesel Fuel Storage and Transfer Areas.

8.10.1* Diesel fuel oil storage tanks shall not be located inside buildings containing other nuclear-safety-related equipment. 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. Potential oil spills shall be confined or directed away from buildings containing safety-related equipment.

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

8.11 Nuclear-Safety-Related Pump Rooms. These rooms shall be protected by fire detection systems. Automatic fire suppression systems shall be provided unless the fire hazards analysis determines that fire suppression is not required. Fire hose stations and fire extinguishers shall be readily accessible.

8.12 New Fuel Area.

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

8.12.2 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.

8.13 Spent Fuel Pool Area. Protection for the spent fuel pool area shall be provided by fire hose stations and fire extinguishers. Fire detection shall be provided in the area.

8.14 Rad Waste and Decontamination Areas. Fire barriers, fire detection, and automatic fire suppression shall be provided as determined by the fire hazards analysis. Manual ventilation control to assist in smoke removal shall be provided if necessary for manual fire fighting.

8.15 Safety-Related Water Tanks. Storage tanks that supply water for fire-safe shutdown shall be protected from the effects of an exposure fire. Combustible materials shall not be stored next to these tanks.

8.16 Record Storage Areas. Record storage areas shall be located and protected in accordance with NFPA 232, *Standard for the Protection of Records*. 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.

8.17 Cooling Towers. Cooling towers shall 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 shall be of noncombustible construction when the basin is used as the ultimate heat sink.

Exception: If combustible construction is used, the cooling towers shall be protected by automatic sprinklers or water spray systems in accordance with NFPA 214, Standard on Water Cooling Towers, and shall be located so that they do not affect safety-related systems or equipment in the event of a fire.

8.18 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.

8.19 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.

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

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

8.22 Fire Pump Room/House. Rooms housing diesel-driven fire pumps shall 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 shall be designed for a minimum density of 0.25 gpm/ft² (10.19 L/min·m²) over the entire fire area.

8.23 Transformers.

8.23.1 Buildings shall 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 as required in Figures 8.23.1(a) and (b) and exposed buildings or by complying with Table 8.23.1. [See Figures 8.23.1(a) and (b).] A minimum 1-hour fire barrier or a distance of 30 ft (9.1 m) shall be provided between adjacent transformers. Means shall be provided to contain oil spills.

Table 8.23.1 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)

8.23.2 Oil-filled main, station service, and start-up transformers shall be protected with automatic water spray systems in accordance with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, or foam-water spray systems in accordance with NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*.

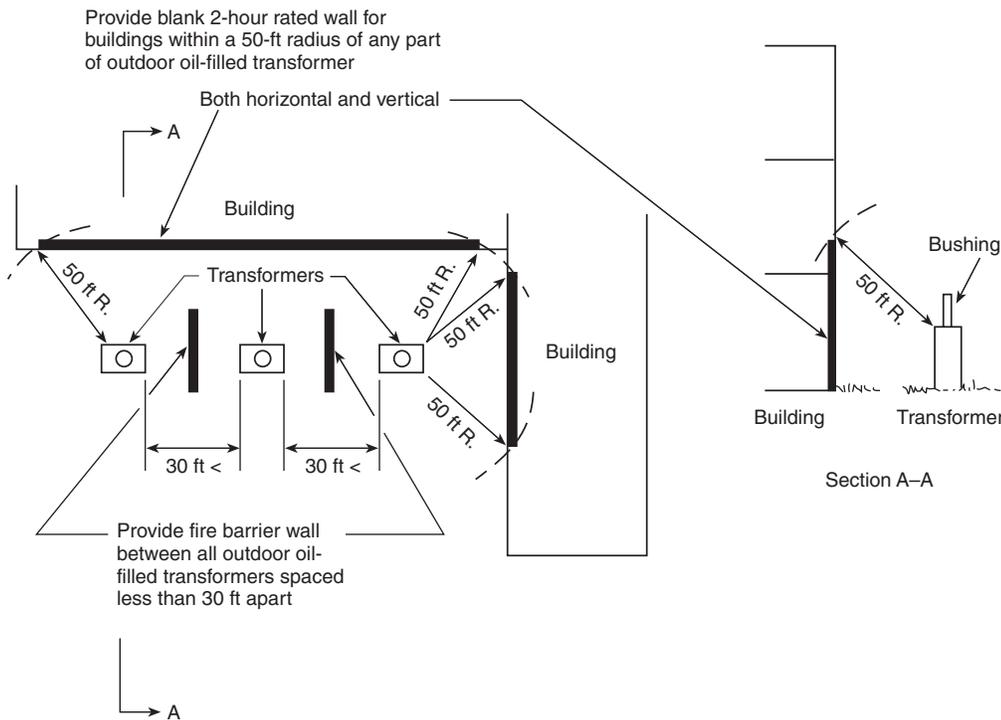
8.23.3 Transformers installed inside fire areas containing safety-related systems or equipment shall be of the dry type or insulated and cooled with noncombustible liquid.

Exception: Transformers filled with combustible fluid that are located indoors shall be enclosed in a transformer vault [see Article 450(c) of NFPA 70].

8.24 Auxiliary Boilers.

8.24.1 Auxiliary boilers, their fuel burning systems, combustion product removal systems, and related control equipment shall be installed and operated in accordance with NFPA 85, *Boiler and Combustion Systems Hazards Code*.

FIGURE 8.23.1(a) Transformer spacing.



For SI units: 1 ft = 0.305 m.

Chapter 9 Fire Protection for the Construction Site

9.1* 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.

9.2 Administration.

9.2.1 The responsibility for fire protection for the entire site during the construction period shall be clearly defined. The administrative responsibilities shall be to develop, implement, and periodically update as necessary the measures outlined in this standard.

9.2.2 The responsibility for fire protection programs among various organizations on-site shall be clearly delineated. The fire protection program to be followed and the owner's right to administration and enforcement shall be established.

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

9.2.4 Written procedures shall be established for the new construction site, including major construction projects in existing plants. Such procedures shall be in accordance with Chapter 3.

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

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

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

9.3 Site Clearing and Construction Equipment.

9.3.1 Site Clearing.

9.3.1.1 Prior to clearing forest and brush-covered areas, the owner shall ensure that a written fire control plan is prepared and that fire-fighting tools and equipment are made available as required by NFPA 295, *Standard for Wildfire Control*. Contact shall be made with local fire and forest agencies for current data on restrictions and fire potential, and to arrange for necessary permits.

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

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

9.3.1.4 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.

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

9.3.1.6* Where it is necessary to dispose of combustible waste by on-site burning, designated burning areas shall be established with 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.

9.4 Construction Warehouses, Shops, and Offices.

9.4.1 All structures that are to be retained as part of the completed plant shall be constructed of materials as indicated in Chapter 6 and in accordance with other applicable sections in this standard.

9.4.2* 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.

9.4.3* A fire risk evaluation shall be performed.

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

9.4.4.1 Building construction materials shall be noncombustible or limited combustible.

9.4.4.2 Automatic sprinkler systems shall be designed and installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*. 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.

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

9.4.5 Temporary enclosures, including trailers, inside permanent plant buildings shall be prohibited except where permitted by the individual responsible for fire prevention and fire protection. Where the floor area of a combustible enclosure exceeds 100 ft² (9.29 m²) or where the occupancy presents a fire exposure, the enclosure shall be protected with an approved automatic fire suppression system.

9.4.6 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 exist:

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

9.4.7 Construction areas comprised of mobile buildings arranged with the buildings adjoining each other to form one large fire area shall be avoided. If buildings cannot be adequately separated, fire walls shall be installed between units or automatic sprinklers shall be provided throughout the buildings.

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

9.4.9 The handling, storage, and dispensing of flammable liquids and gases shall meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*, NFPA 58, *Liquefied Petroleum Gas Code*, and NFPA 395, *Standard for the Storage of Flammable and Combustible Liquids at Farms and Isolated Sites*.

9.4.10 Vehicle repair facilities shall meet the requirements of NFPA 88B, *Standard for Repair Garages*.

9.5 Construction Site Lay-Down Areas.

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

9.5.2 Combustible materials shall be separated by a clear space to allow access for manual fire-fighting equipment. Access shall be provided and maintained to all fire-fighting equipment including fire hoses, extinguishers, and hydrants.

9.6 Temporary Construction Materials.

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

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

9.6.3 Tarpaulins (fabrics) and plastic films shall be certified to conform to the weather-resistant and fire-retardant materials described in NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*.

9.6.4 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 combustible materials, security, nuclear criticality, packing material, noncombustible or limited-combustible building materials, standpipe, portable fire extinguishers, and hydrant protection.

9.7 Water Supplies, Supply Mains, and Hydrants.

9.7.1* General. The permanent underground yard system, fire hydrants, and water supply (at least one water source), as indicated in Chapter 6, shall be installed during the early stages of construction. Where provision of all or part of the permanent underground system and water supply is not practical, temporary systems shall be provided. 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.

9.7.2 Hydrants shall be installed, as indicated in Chapter 6, in the vicinity of main plant buildings, important warehouses, office or storage trailer complexes, and important outside structures with combustible construction or combustible concrete formwork (e.g., cooling towers). 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.

9.7.3 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

9.7.3.1 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.

9.7.3.2* 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 adequate to meet the designed system demand. However, when the permanent hazard is introduced, the water supply shall be capable of providing the designed system demand. Where using construction water in permanent systems, adequate strainers shall be provided to prevent clogging of the system by foreign objects and dirt.

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

9.8 Manual Fire-Fighting Equipment.

9.8.1* Fire-fighting equipment shall be provided in accordance with NFPA 600, *Standard on Industrial Fire Brigades*, and NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*.

9.8.2 Portable fire extinguishers of suitable capacity shall be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*, where one or more of the following occurs:

- (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.

9.8.3* A standpipe system shall be provided in any permanent building that has two-floor equivalent wall heights erected. Additional standpipe hose connections shall be added to each floor level as soon as sufficient landings are available to fight fires from that level. Protection from freezing shall be provided.

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

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

Chapter 10 Referenced Publications

10.1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix B.

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

NFPA 10, *Standard for Portable Fire Extinguishers*, 1998 edition.

NFPA 11, *Standard for Low-Expansion Foam*, 1998 edition.

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, 1999 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2000 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1999 edition.

NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems*, 2000 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 1996 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 1999 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 1998 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 1999 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 1998 edition.

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

NFPA 30, *Flammable and Combustible Liquids Code*, 2000 edition.

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

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 1998 edition.

NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, 1999 edition.

NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites*, 1999 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 1999 edition.

NFPA 54, *National Fuel Gas Code*, 1999 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2001 edition.

NFPA 70, *National Electrical Code*[®], 1999 edition.

NFPA 72, *National Fire Alarm Code*[®], 1999 edition.

NFPA 75, *Standard for the Protection of Electronic Computer/Data Processing Equipment*, 1999 edition.

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

NFPA 85, *Boiler and Combustion Systems Hazards Code*, 2001 edition.

NFPA 88B, *Standard for Repair Garages*, 1997 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 1999 edition.

NFPA 101[®], *Life Safety Code*[®], 2000 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, 2000 edition.

NFPA 214, *Standard on Water-Cooling Towers*, 2000 edition.

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

NFPA 232, *Standard for the Protection of Records*, 2000 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*, 2000 edition.

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

NFPA 252, *Standard Methods of Fire Tests of Door Assemblies*, 1999 edition.

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

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

NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*, 1998 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 1998 edition.

NFPA 295, *Standard for Wildfire Control*, 1998 edition.

NFPA 395, *Standard for the Storage of Flammable and Combustible Liquids at Farms and Isolated Sites*, 1993 edition.

NFPA 600, *Standard on Industrial Fire Brigades*, 2000 edition.

NFPA 601, *Standard for Security Services in Fire Loss Prevention*, 2000 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*, 1999 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 1997 edition.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, 1997 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2000 edition.

10.1.2 Other Publications.

10.1.2.1 ANSI Publications. American National Standards Institute, Inc., 11 West 42nd Street 13th floor, New York, NY 10036.

ANSI B31.1, *Code for Power Piping*, 1992 edition.

ANSI C2, *National Electrical Safety Code*, 1993 edition.

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

ASME Boiler and Pressure Vessel Code, Section III, 1992 edition.

ASME NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities*, 1994 edition.

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

ASTM D 92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup*, 1990 edition.

ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 1994 edition.

ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, 1988 edition.

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

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

10.1.2.4 IEEE Publication. Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

IEEE 383-1974 (R-1992) *Standard for Type Test of Class IE Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations*.

10.1.2.5 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 586, *Standard for Test Performance of High-Efficiency Particulate Air Filter Units*, 1990 edition.

UL 1479, *Standard for Safety Fire Tests of Through-Penetration Firestops*, 1994 edition.

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

NRC Generic Letter 86-10, Supplement 1.

Title 10, *Code of Federal Regulations*, Part 100, "Reactor Site Criteria."

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix 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, *Standard for Fire Protection for Facilities Handling Radioactive Materials*.

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

A.1.4.1 Advanced Light Water Reactors (ALWR). 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 completely rethinking 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.1.4.3 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.1.4.4 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.1.4.5 Authority Having Jurisdiction. The phrase “authority having jurisdiction” 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.1.4.8 Combustible. Any material that in the form in which it is used and under the conditions anticipated will ignite and burn. A material that does not meet the definition of *noncombustible* or *limited-combustible*.

A.1.4.10 Defense in Depth. None of the fire protection defense in depth elements is complete by itself. Strengthening any defense in depth elements can compensate for known or unknown weaknesses in the other factors.

A.1.4.11 Fire Area. That portion of a building or plant that is separated from other areas by boundary fire barriers.

A.1.4.12 Fire Area Subdivision. The phrase *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 has created two separate phrases: *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), which is protected by its own sprinkler system, and detection that annunciates an alarm specifically for the pump bay. It is acceptable to describe such a location as both a fire area subdivision and a fire zone.

A.1.4.14 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.1.4.20 Fire-Rated Cables. At this time, there is no nationally recognized standard to test and qualify fire-rated cables. The cables should be tested in accordance with the time-temperature curve in NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*. The cables should remain functional for the required rating period.

A.1.4.25 Fire-Safe Shutdown Component. These components are not necessarily nuclear safety related.

A.1.4.26 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.1.4.31 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 overpressurizing the low-pressure system.

A.1.4.34 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.1.4.37 Nuclear Safety Function. These guidelines can be found in 10 *CFR* 100, “Reactor Site Criteria.”

A.1.4.38 Nuclear Safety Related. These guidelines can be found in 10 *CFR* 100, “Reactor Site Criteria.”

A.1.4.40 Power Block. Containment, auxiliary building, service building, control building, fuel building, rad waste, water

treatment, turbine building, and intake structure are examples of power block structures.

A.1.4.43 Safety Division. The terms *division*, *train*, and *separation group* are interchangeable when used in the context of this definition.

A.1.4.46 Spurious Operation. These operations include but are not limited to the following:

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

A.2.1 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.2.4 Where any of the analyses in Section 2.4 have been performed elsewhere, they need only be referenced as part of the fire hazards analysis.

A.2.4(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.2.6.1(2) Inspections, tests, administrative controls, fire drills, and training that govern the fire protection program should be prescribed by documented instructions, procedures, or drawings and should be accomplished in accordance with these documents.

A.2.6.1(3) Measures should be established to ensure that purchased material, equipment, and services conform to the procurement documents.

A.2.6.1(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.2.6.1(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; test results should be properly evaluated and acted on.

A.2.6.1(6) Measures should be established to provide for the identification of items that have satisfactorily passed necessary tests and inspections.

A.2.6.1(7) Measures should be established to control items that do not conform to specified requirements to prevent inadvertent use or installation.

A.2.6.1(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.2.6.1(9) Records should be prepared and maintained to furnish evidence that the criteria enumerated in 2.6.1 are being met for activities affecting the fire protection program.

A.2.6.1(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.3.1 This chapter sets forth the minimum requirements necessary for the administrative controls and fire prevention activities.

This chapter 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 3. 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 already 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.3.3.1 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 out-breaks of fire occur for a variety of reasons.

A.3.3.1.1 Typical examples of flammable and combustible materials found in a nuclear power plant include one or more of 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 (e.g., oil-bath filters, charcoal, etc.)
- (6) Cleansing materials
- (7) Paints and solvents
- (8) Packaging materials (e.g., 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 (H₂) by radiolysis in the core and addition of H₂ for improved recombination
- (4) Gas for cutting and welding
- (5) Oxygen (O₂) (While not a flammable gas, it is an oxidizer and 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, or both, 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.3.3.1.2 Typical examples include one or more of 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.3.3.3.1 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.3.3.3.4 Particular attention should be given to the control of halogenated plastics.

A.3.3.4.4(1) Oil pipes should be located below steam lines.

A.3.4.1.3 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 his or her 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.3.5.1.1 Grouped noncombustible buildings, trailers, and sheds with separation between individual units less than that specified by NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, 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, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*.)

A.3.6.1 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, the insurance company, etc.)

- (3) Compensatory measures (e.g., increased surveillance on other systems, fire watch patrols)
- (4) Target durations for impaired equipment (i.e., escalation of management attention to impaired equipment to ensure prompt corrective action)
- (5) Consideration of plant status (i.e., compensatory measures can be relaxed for impairment of certain systems during outage conditions)

This list can be modified as needed to include any 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.3.6.2 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.3.6.3 Post-maintenance 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 3.7 and the appropriate NFPA standard addressing the type of system impaired should be used when considering the type of post-maintenance testing that is necessary.

A.3.7.2 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.3.7.2 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 these 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 only be accessible during outages. Water disposal considerations might limit certain sprinkler system tests within radioactive controlled areas.

A.3.7.4 Certain plant systems and equipment, including the turbine generator, transformers, large pumps, and so forth, will have a large 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 this testing is adequate to minimize the fire risk.

A.4.1.2 Water drainage methods should be reviewed and included in that area's prefire plans.

A.4.1.4 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.

Table A.3.7.2 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	11A, 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 hydrants and associated valves	24, 25
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.4.2 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 department
- (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. This 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.4.3.1.2 This 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.4.4.1 This 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.4.5.2.3 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.4.5.3.1 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.4.9 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.5.1 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.5.2.2.2 See Figure A.5.2.2.2.

A.5.2.3.1 Currently the fire-induced vulnerability evaluation (FIVE) methodology and fire probabilistic risk assessment (PRA) are available.

A.5.2.3.2 The value of 1×10^{-6} per reactor year is based on NRC Generic Letter 88-20, Supplement 4.

A.5.3.1.2 These components include nuclear-safety-related and safe shutdown components. Components outside the fire area that are electrically or mechanically dependent upon fire-damaged components within the fire area should be considered within the analysis.

A.5.3.1.3 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.

A.5.3.1.8(3) Due to their design, revolutionary plants will achieve and maintain cold shutdown conditions only after an extended period of time.

A.5.3.1.12 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.5.3.1.14 These devices protect the function of the safety circuit in the event of fire damage to the associated circuits of concern.

A.5.3.1.15 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.5.3.2 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.5.3.2.2 Guidance is provided in NRC Generic Letter 88-20, Supplement 4, "Sandia Risk Scoping Items."

A.5.5.2.2 Repairs such as lifting leads or pulling of fuses should not be necessary to achieve shutdown of the reactor.

A.5.5.3.1.1 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.5.5.3.2.1 Operators should not be required to perform any unsafe physical actions.

A.5.5.3.2.2 Operators should not be required to perform any physical operations that are outside of their normal physical abilities.

A.6.2.1 Conformance with the NFPA 101®, *Life Safety Code*®, satisfies OSHA requirements for means of egress.

A.6.2.2 The operation and maintenance of an ALWR plant involves unique operations and materials in process.

A.6.3.2 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 hydrocarbons. When burning, they produce heavy smoke that obscures visibility and can plug air filters, especially charcoal and HEPA filters. The halogenated plastics also release free chloride and hydrogen chloride when burning, which are toxic to humans and corrosive to equipment.

A.6.3.7.2 This will minimize the possibility of wall penetration in the event of a container failure.

A.6.4 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.6.4.1 For further information, see NFPA 92A, *Recommended Practice for Smoke-Control Systems*, and NFPA 204, *Guide for Smoke and Heat Venting*.

A.6.4.2 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.6.4.3.3 This includes containment functions for protecting the public and maintaining habitability for operations personnel.

A.6.4.9.3 Exception No. 2. Figure A.6.4.9.3 shows a typical air duct fire damper configuration.

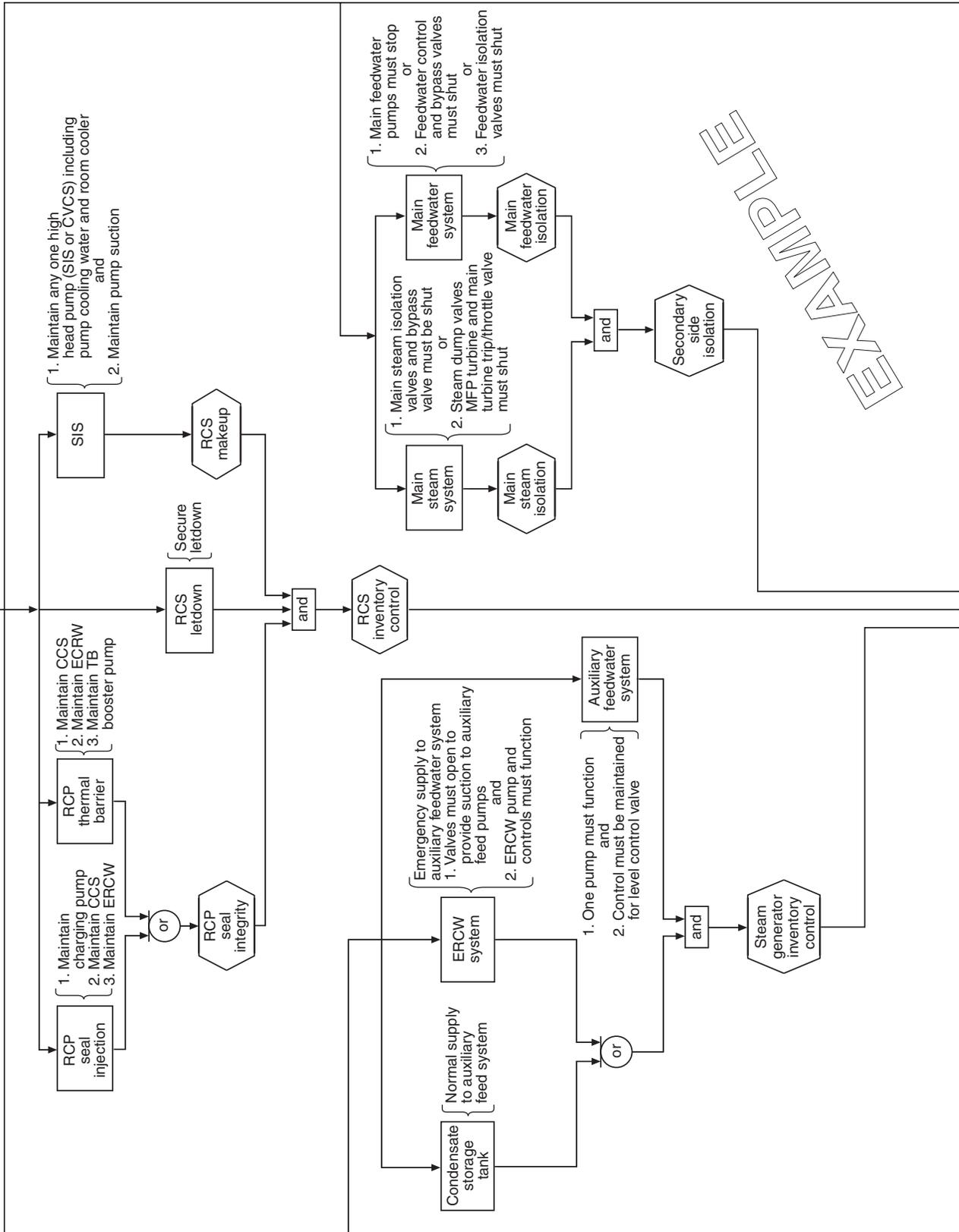
A.6.5.1 Refer to Appendix A of NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, for additional information on drainage.

A.6.5.3(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.6.9 See NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*.

A.6.11.2 Multi-channel portable radios are used for communications at nuclear power plants. Subsections 6.11.2 and 6.11.3 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.5.2.2.2. Typical shutdown logic diagram — fire. (Source: ANS-59.4-1979)



EXAMPLER