NFPA® 805

Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants

2010 Edition

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NFPA® 805

Performance-Based Standard for

Fire Protection for Light Water Reactor Electric Generating Plants

2010 Edition

This edition of NFPA 805, *Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants*, was prepared by the Technical Committee on Fire Protection for Nuclear Facilities. It was issued by the Standards Council on October 27, 2009, with an effective date of December 5, 2009, and supersedes all previous editions.

This edition of NFPA 805 was approved as an American National Standard on December 5, 2009.

Origin and Development of NFPA 805

The 2001 edition of NFPA 805 was the first edition of this standard. NFPA 805 replaced NFPA 803, *Standard for Fire Protection for Light Water Nuclear Power Plants*. NFPA 805 is a performance-based standard that describes the methodology for applying performance-based requirements, fundamental fire protection program design and elements, determination of fire protection systems and features, and fire protection during decommissioning and permanent shutdown of light water reactor electric generating plants.

The 2006 edition was reformatted to comply with the *Manual of Style for NFPA Technical Committee Documents* and to incorporate new information from the EPRI Fire Modeling Guide and NUREG 1805.

The 2010 edition has been revised to coordinate with the new NFPA 806. Personnel considerations have been removed from the methodology for defining the fire scenario because, as a life safety issue, they do not belong as a component.

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Technical Committee on Fire Protection for Nuclear Facilities

William B. Till, Jr., *Chair*
Savannah River Nuclear Solutions, LLC, SC [U]

Kevin Austin, Bruce Power, Canada [U]
James B. Biggins, Marsh Risk Consulting, IL [I]
William G. Boyce, U.S. Department of Energy, DC [E]
Harry M. Corson, IV, Siemens Fire Safety, NJ [M]
Rep. National Electrical Manufacturers Association
Stanford E. Davis, PPL Susquehanna LLC, PA [U]
Edgar G. Dressler, The Villages, FL [I]
Rep. American Nuclear Insurers
David R. Estrela, Orr Protection Systems, Inc., MA [IM]
Arie T. P. Go, Bechtel Corporation, CA [SE]
Wayne D. Holmes, HSB Professional Loss Control, NC [I]
Daniel J. Hubert, Janus Fire Systems, IN [IM]
Robert Kalantari, EPM, Incorporated, MA [SE]
Robert P. Kassawara, Electric Power Research Institute, CA [U]
Elizabeth A. Kleinsorg, Kleinsorg Group Risk Services, LLC, CA [SE]
Neal W. Krantz, Krantz Systems & Associates, LLC, MI [IM]
Rep. Automatic Fire Alarm Association, Inc.
Christopher A. Ksobiech, We Energies, WI [U]
Paul W. Lain, U.S. Nuclear Regulatory Commission, DC [E]
Frank Monikowski, Tyco/SimplexGrinnell, PA [M]
Rep. National Fire Sprinkler Association
Bijan Najafi, Science Applications International Corp. (SAIC), CA [SE]
Joseph G. Redmond, AREVA NP, Inc., NC [M]
Ronald Rispoli, Entergy Corporation, AR [U]
Rep. Nuclear Energy Institute
William M. Shields, U.S. Defense Nuclear Facilities Safety Board, DC [E]
Clifford R. Sinopoli, II, Exelon Corporation, PA [U]
Rep. Edison Electric Institute
Wayne R. Sohlman, Nuclear Electric Insurance Ltd., DE [I]
James R. Streit, Los Alamos National Laboratory, NM [U]
William M. Sullivan, Contingency Management Associates, Inc., MA [SE]
Ronald W. Woodfin, TetraTek, Inc. Fire Safety Technologies, TX [SE]

Alternates

James Bouche, F. E. Moran, Inc. Special Hazard Systems, IL [M]
(Alt. to F. Monikowski)
Craig P. Christenson, U.S. Department of Energy, WA [E]
(Alt. to W. G. Boyce)
Richard L. Dible, AREVA NP, Inc., TX [M]
(Alt. to J. G. Redmond)
Jeffery S. Ertman, Progress Energy, NC [U]
(Alt. to C. A. Ksobiech)
Daniel M. Frumkin, U.S. Nuclear Regulatory Commission, MD [E]
(Alt. to P. W. Lain)
Thomas K. Furlong, Nuclear Service Organization, DE [I]
(Alt. to W. R. Sohlman)
John P. Gaertner, Electric Power Research Institute, NC [U]
(Alt. to R. P. Kassawara)
Frank S. Gruscavage, PPL Susquehanna LLC , PA [U]
(Alt. to S. E. Davis)
Jack A. Gump, HSB Global Standards, TN [I]
(Alt. to W. D. Holmes)
David M. Hope, TetraTek Inc. Fire Safety Technologies, TN [SE]
(Alt. to R. W. Woodfin)
James W. Naylor, Washington Savannah River Company, SC [U]
(Alt. to W. B. Till, Jr.)
Paul R. Ouellette, EPM, Incorporated, MA [SE]
(Alt. to R. Kalantari)
Andrew R. Ratchford, Ratchford Diversified Services, LLC, CA [SE]
(Alt. to E. A. Kleinsorg)
Robert K. Richter, Jr., Southern California Edison Company, CA [U]
(Alt. to R. Rispoli)
Cleveland B. Skinker, Bechtel Power Corporation, MD [SE]
(Alt. to A. T. P. Go)

Nonvoting

Tzu-sheng Shen, Central Police University, Taiwan [SE]
Leonard R. Hathaway, The Villages, FL [I]
(Member Emeritus)
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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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Performance-Based Standard for

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

Chapter 1 Administration

1.1 Scope. This standard specifies the minimum fire protection requirements for existing light water nuclear power plants during all phases of plant operation, including shutdown, degraded conditions, and decommissioning.

1.2 Purpose. Protecting the safety of the public, the environment, and plant personnel from a plant fire and its potential effect on safe reactor operations is paramount to this standard. The fire protection standard shall be based on the concept of defense-in-depth. Defense-in-depth shall be achieved when an adequate balance of each of the following elements is provided:

(1) Preventing fires from starting
(2) Rapidly detecting fires and controlling and extinguishing promptly those fires that do occur, thereby limiting fire damage
(3) Providing an adequate level of fire protection for structures, systems, and components important to safety, so that a fire that is not promptly extinguished will not prevent essential plant safety functions from being performed

1.3 Goals.

1.3.1 Nuclear Safety Goal. The nuclear safety goal shall be to provide reasonable assurance that a fire during any operational mode and plant configuration will not prevent the plant from achieving and maintaining the fuel in a safe and stable condition.

1.3.2 Radioactive Release Goal. The radioactive release goal shall be to provide reasonable assurance that a fire will not result in a radiological release that adversely affects the public, plant personnel, or the environment.

1.3.3* Life Safety Goal. The life safety goal shall be to provide reasonable assurance that loss of life in the event of fire will be prevented for facility occupants.

1.3.4 Plant Damage/Business Interruption Goal. The plant damage/business interruption goal shall be to provide reasonable assurance that the risks of fire are acceptable with regard to potential economic consequences.

1.4 Performance Objectives.

1.4.1 Nuclear Safety Objectives. In the event of a fire during any operational mode and plant configuration, the plant shall be provided with the following:

(1) Reactivity control, which is the capability of rapidly achieving and maintaining subcritical conditions
(2) Fuel cooling, which is the capability of achieving and maintaining decay heat removal and inventory control functions
(3) Fission product boundary, which is the capability of preventing fuel clad damage so that the primary containment boundary is not challenged

1.4.2 Radioactive Release Objective. Either of the following objectives shall be met during all operational modes and plant configurations:

(1) Containment integrity is capable of being maintained.
(2) The source term is capable of being limited.

1.4.3 Life Safety Objectives. The life safety objectives shall be to protect occupants not intimate with the initial fire development from loss of life and improve the survivability of those who are intimate with the fire development, as well as to provide protection for essential and emergency personnel.

1.4.4 Plant Damage/Business Interruption Objectives. In order to meet the plant damage/business interruption goals, the following objectives shall be met during all operational modes and plant configurations.

(1) Potential property damage due to fire shall be limited to an acceptable level as determined by the owner/operator.
(2) Potential business interruption (plant downtime) due to fire shall be limited to an acceptable level as determined by the owner/operator.

1.5 Performance Criteria.

1.5.1 Nuclear Safety Performance Criteria. Fire protection features shall be capable of providing assurance that, in the event of a fire, the plant is not placed in an unrecoverable condition.

1.5.2 To demonstrate the capability required by 1.5.1, the following performance criteria shall be met:

(1) *Reactivity Control.* Reactivity control shall be capable of inserting negative reactivity to achieve and maintain subcritical conditions, and inserting shall occur rapidly enough such that fuel design limits are not exceeded.
(2) *Inventory and Pressure Control.* With fuel in the reactor vessel, head on and tensioned, inventory and pressure control shall be capable of the following:
    (a) Controlling coolant level such that level indication is maintained in the pressurizer for a pressurized water reactor (PWR)

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(b) Maintaining or rapidly restoring reactor water level above the top of active fuel for a boiling water reactor (BWR) such that fuel clad damage as a result of a fire is prevented

(3) *Decay Heat Removal.* Decay heat removal shall be capable of removing sufficient heat from the reactor core or spent fuel such that fuel is maintained in a safe and stable condition.

(4) *Vital Auxiliaries.* Vital auxiliaries shall be capable of providing the necessary auxiliary support equipment and systems to ensure that the systems required under 1.5.2(1), 1.5.2(2), 1.5.2(3), and 1.5.2(5) are capable of performing their required nuclear safety function.

(5)**Process Monitoring.* Process monitoring shall be capable of providing the necessary indication to ensure that the criteria addressed in 1.5.2(1) through 1.5.2(4) have been achieved and are being maintained.

1.5.3 Radioactive Release Performance Criteria. Radiation release to any unrestricted area due to the direct effects of fire suppression activities (but not involving fuel damage) shall be as low as reasonably achievable and shall not exceed applicable 10 CFR 20 limits.

1.5.4 Life Safety Criteria. The following performance criteria shall be met during all operational modes and plant configurations:

(1) Provision of safe egress and/or area of refuge for occupants other than essential personnel
(2) Provision of protection, including emergency lighting, for essential personnel to perform necessary safety functions as a result of a fire event
(3) Provision of protection for essential personnel, providing necessary emergency services during or following a fire

1.5.5* Plant Damage/Business Interruption Criteria. In order to meet the individual plant damage/business interruption objectives, the following criteria shall be satisfied:

(1) The probable maximum loss (PML) shall not exceed an acceptable level as determined by the owner/operator.
(2) The business interruption (plant downtime) due to a PML fire event shall not exceed an acceptable level as determined by the owner/operator.

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

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

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

1.7 Code of Record. The codes and standards referenced in this standard refer to the edition of the code or standard in effect at the time the fire protection systems or feature was designed or specifically committed to the authority having jurisdiction.

Chapter 2 Referenced Publications

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

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

NFPA 10, *Standard for Portable Fire Extinguishers,* 2010 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 2008 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems,* 2009 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2010 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2010 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2007 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems,* 2007 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2010 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2008 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 2010 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2008 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* 2009 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code,* 2010 edition.

NFPA 72®, National Fire Alarm and Signaling Code, 2010 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives,* 2010 edition.

NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures,* 2007 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* 2009 edition.

NFPA *101®, Life Safety Code®,* 2009 edition.

NFPA 220, *Standard on Types of Building Construction,* 2009 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations,* 2009 edition.

NFPA 251, *Standard Methods of Tests of Fire Resistance of Building Construction and Materials,* 2006 edition.

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

NFPA 600, *Standard on Industrial Fire Brigades,* 2010 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films,* 2010 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems,* 2010 edition.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program,* 2007 edition.

NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments,* 2007 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems,* 2008 edition.

2.3 Other Publications.

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

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

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

ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials,* 2005.

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ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, 1997.

2.3.3 NRC Publications. U.S. Nuclear Regulatory Commission, Public Document Room, Washington, DC 20555-0001.

Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant Specific Changes to the Licensing Basis."

Generic Letter 86-10, Supplement 1, "Fire Endurance Test Acceptance Criteria for Fire Barrier Systems Used to Separate Safe Shutdown Trains Within the Same Fire Area."

Generic Letter 86-10, Supplement 1, Attachment 1, "Attachment Methods for Demonstrating Functionality of Cables Protected by Raceway Fire Barrier Systems During and After Fire Endurance Test Exposure."

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

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

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

Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation."

Title 10, Code of Federal Regulations, Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix R to Part 50, Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979.

2.3.6 Other Publications.

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

2.4 References for Extracts in Mandatory Sections. (Reserved)

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

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

3.2.5 Shall. Indicates a mandatory requirement.

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

3.2.7 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Acceptable. Considered by the authority having jurisdiction (AHJ) as adequate for satisfying the goals, performance objectives, and/or performance criteria.

3.3.2 Action.

3.3.2.1 ***Compensatory Action.*** Actions taken if an impairment to a required system, feature, or component prevents that system, feature, or component from performing its intended function. These actions are a temporary alternative means of providing reasonable assurance that the necessary function will be compensated for during the impairment, or an act to mitigate the consequence of a fire. Compensatory measures include but are not limited to actions such as firewatches, administrative controls, temporary systems, and features of components.

3.3.2.2 ***Recovery Action.*** Activities to achieve the nuclear safety performance criteria that take place outside of the main control room or outside of the primary control station(s) for the equipment being operated, including the replacement or modification of components.

3.3.3 Analysis.

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

3.3.3.2 ***Uncertainty Analysis.*** An analysis intended to (1) identify key sources of uncertainties in the predictions of a model, (2) assess the potential impacts of these uncertainties on the predictions, and (3) assess the likelihood of these potential impacts. Per this definition, sensitivity analysis performs some but not all of the functions of uncertainty analysis. *(See also 3.3.42.1, Completeness Uncertainty; 3.3.42.2, Model Uncertainty; and 3.3.42.3, Parameter Uncertainty.)*

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3.3.4 Approach.

3.3.4.1 ***Deterministic Approach.*** An approach that establishes requirements for engineering margin and quality assurance in design, manufacture, and construction. It involves implied, but unquantified, elements of probability in the selection of the specific accidents to be analyzed as design basis events. It does not integrate results in a comprehensive manner to assess the overall impact of postulated initiating events.

3.3.4.2 ***Performance-Based Approach.*** An approach that relies upon measurable (or calculable) outcomes (i.e., performance results) to be met but provides more flexibility as to the means of meeting those outcomes. A performance-based approach is one that establishes performance and results as the primary basis for decision-making and incorporates the following attributes: (1) Measurable or calculable parameters exist to monitor the system, including facility performance; (2) objective criteria to assess performance are established based on risk insights, deterministic analyses, and/or performance history; (3) plant operators have the flexibility to determine how to meet established performance criteria in ways that will encourage and reward improved outcomes; and (4) a framework exists in which the failure to meet a performance criterion, while undesirable, will not in and of itself constitute or result in an immediate safety concern.

3.3.4.3* ***Risk-Informed Approach.*** A philosophy whereby risk insights are considered together with other factors to establish performance requirements that better focus attention on design and operational issues commensurate with their importance to public health and safety.

3.3.5 As Low As Reasonably Achievable (ALARA). Making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part [10 CFR 20] as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest. **[10 CFR 20]**

3.3.6 Availability. The probability that the system, structure, or component of interest is functional at a given point in time.

3.3.7* Combustible. Capable of undergoing combustion.

3.3.7.1 ***In Situ Combustible.*** Combustible materials that are permanently located in a room or an area (e.g., cable insulation, lubricating oil in pumps).

3.3.7.2 ***Limited Combustible.*** In nuclear facilities, a material that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg) and either has a structural base of noncombustible material with a surfacing not exceeding a thickness of ⅛ in. (3.2 mm) that has a flame spread rating not greater than 50, or has another material having neither a flame spread rating greater than 25 nor evidence of continued progressive combustion, even on surfaces exposed by cutting through the material on any plane.

3.3.8 Containment. Structures, systems, or components provided to prevent or mitigate the release of radioactive materials.

3.3.9 Damage.

3.3.9.1 ***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.

3.3.9.2 ***Fuel Damage.*** Exceeding the fuel design limits.

3.3.10 Essential Personnel. Personnel who are required to perform functions to mitigate the effects of a fire, including but not limited to industrial fire brigade members, operations, health physics, security, and maintenance.

3.3.11* 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.

3.3.12* Fire Barrier. In nuclear facilities, a continuous assembly designed and constructed to limit the spread of heat and fire and to restrict the movement of smoke.

3.3.13* Fire Compartment. A subdivision of a building or plant that is a well-defined enclosed room, not necessarily bounded by rated fire barriers. A fire compartment generally falls within a fire area and is bounded by noncombustible barriers where heat and products of combustion from a fire within the enclosure will be substantially confined.

3.3.14 Fire Door Assembly. Any combination of a fire door, a frame, hardware, and other accessories that together provide a specific degree of fire protection to the opening.

3.3.15 Fire Model. Mathematical prediction of fire growth, environmental conditions, and potential effects on structures, systems, or components based on the conservation equations or empirical data.

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

3.3.17 Fire Protection Feature. Administrative controls, fire barriers, means of egress, industrial fire brigade personnel, and other features provided for fire protection purposes.

3.3.18 Fire-Rated Penetration. See 3.3.41, Through Penetration Fire Stop.

3.3.19 Fire Scenario. In nuclear facilities, a description of a fire and any factors affecting or affected by it from ignition to extinguishment, including, as appropriate, ignition sources, nature and configuration of the fuel, ventilation characteristics, locations of occupants, condition of the supporting structure, and conditions and status of operating equipment.

3.3.19.1 ***Limiting Fire Scenarios.*** Fire scenario(s) in which one or more of the inputs to the fire modeling calculation (e.g., heat release rate, initiation location, or ventilation rate) are varied to the point that the performance criterion is not met. The intent of this scenario(s) is to determine that there is a reasonable margin between the expected fire scenario conditions and the point of failure. *(See Annex C for a discussion of limiting fire scenarios and margin.)*

3.3.19.2 ***Maximum Expected Fire Scenarios.*** Scenarios that represent the most challenging fire that could be reasonably anticipated for the occupancy type and conditions in the space. These scenarios can be established based on electric power industry experience with consideration for plant-specific conditions and fire experience. *(See Annex C for a list of industry examples of fire scenarios for typical plant areas.)*

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3.3.20 Flame Spread Index. A comparative measure, expressed as a dimensionless number, derived from visual measurements of the spread of flame versus time for a material tested in accordance with ASTM E 84 or ANSI/UL 723.

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

3.3.22 Large Early Release. Significant, unmitigated release from containment in a time frame prior to effective evacuation of the close-in population such that there is a potential for early health effects. **[NRC Regulatory Guide 1.174]**

3.3.23 Liquid.

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

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

3.3.24 Noncombustible Material. In nuclear facilities, a material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.

3.3.25 Owner/Operator. The organization(s) with fiscal responsibility for the operation, maintenance, and profitability of the nuclear plant.

3.3.26 Performance Criteria. Specific measurable or calculable parameters for systems and features that are quantified and described in engineering terms.

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

3.3.28 Prior Distribution. Probability distribution quantifying the analyst's state of knowledge regarding the parameter to be estimated prior to collection of new data.

3.3.29 Probabilistic Safety Assessment (PSA). A comprehensive evaluation of the risk of a facility or process; also referred to as a probabilistic risk assessment (PRA).

3.3.30 Probable Maximum Loss (PML). The loss due to a single fire scenario, which assumes an impairment to one suppression system and a possible delay in manual fire-fighting response.

3.3.31 Radiant Energy Shield. A device utilized to protect components from the effects of radiant heat generated by a fire.

3.3.32 Rating.

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

3.3.32.2 ***Flame Spread Rating.*** A relative measurement of the surface burning characteristics of building materials when tested in accordance with ASTM E 84 or ANSI/UL 723.

3.3.33 Reactor.

3.3.33.1 ***BWR.*** Boiling water reactor.

3.3.33.2 ***PWR.*** Pressurized water reactor.

3.3.34 Reliability. The probability that the system, structure, or component of interest will function without failure for a given interval of time or number of cycles. For standby systems, structures, or components, this includes the probability of success upon demand.

3.3.35 Risk. In nuclear facilities, the set of probabilities and consequences for all possible accident scenarios associated with a given plant or process.

3.3.36 Safe and Stable Conditions. For fuel in the reactor vessel, head on and tensioned, safe and stable conditions are defined as the ability to maintain $K_{eff} < 0.99$, with a reactor coolant temperature at or below the requirements for hot shutdown for a boiling water reactor and hot standby for a pressurized water reactor. For all other configurations, safe and stable conditions are defined as maintaining $K_{eff} < 0.99$ and fuel coolant temperature below boiling.

3.3.37 Site. The contiguous property that makes up a nuclear power plant facility. This would include areas both inside the protected area and the owner-controlled property.

3.3.38 Source Term Limitation. Limiting the source of radiation available for release.

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

3.3.40 System.

3.3.40.1 ***Electrical Raceway Fire Barrier System (ERFBS).*** Non-load-bearing partition-type envelope system installed around electrical components and cabling that have withstood a fire exposure as established in accordance with an approved test procedure and are rated by a test laboratory in hours of fire resistance and are used to maintain specified nuclear safety functions free of fire damage.

3.3.40.2 ***Fire Protection System.*** Any fire alarm device or system or fire extinguishing device or system, or their combination, that is designed and installed for detecting, controlling, or extinguishing a fire or otherwise alerting occupants, or the fire department, or both, that a fire has occurred.

3.3.40.3 ***Fire-Rated Cable Encapsulation Systems.*** See 3.3.40.1, Electrical Raceway Fire Barrier System (ERFBS).

3.3.41* Through Penetration Fire Stop. A tested, fire-rated construction consisting of the materials that fill the openings through the wall or floor opening around penetrating items such as cables, cable trays, conduits, ducts, and pipes and their means of support to prevent the spread of fire.

3.3.42 Uncertainty.

3.3.42.1 ***Completeness Uncertainty.*** Uncertainty in the predictions of a model due to model scope limitations. This uncertainty reflects an unanalyzed contribution or reduction of risk due to limitations of the available analytical methods.

3.3.42.2 ***Model Uncertainty.*** Uncertainty in the predictions of a model related to the equations in the model being correct, whether or not they are appropriate to the problem being solved, and whether or not they are sufficiently complete.

3.3.42.3 ***Parameter Uncertainty.*** Uncertainty in the predictions of a model due to uncertainties in the numerical values of the model parameters.

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Chapter 4 Methodology

4.1 Intent.

4.1.1 The intent of this chapter shall be to describe the general approach for establishing the fire protection requirements for a nuclear power plant.

4.1.2 This chapter shall provide the requirements for the engineering analyses used to establish the required fire protection systems and features, including in particular the analyses used to support the performance-based fire protection design that fulfills the goals, objectives, and criteria provided in Chapter 1.

4.2* General Approach. The general approach of this standard shall involve the following steps in accordance with Figure 4.2:

(1) Establishment of the fundamental fire protection program *(see Chapter 5)*.
(2) Identification of fire areas and associated fire hazards.
(3) Identification of the performance criteria that apply to each fire area *(see Section 1.5)*.
(4) Identification of systems, structures, and components (SSCs) in each fire area to which the performance criteria apply.
(5) Selection of the deterministic and/or performance-based approach for the performance criteria *(see Chapter 6)*.
(6) When applying a deterministic approach, demonstration of compliance with the deterministic requirements *(see Chapter 6)*.
(7) When applying a performance-based approach, performance of engineering analyses, including, for example, engineering evaluations, probabilistic safety, assessments, or fire modeling calculations, to demonstrate that performance-based requirements are satisfied *(see Section 4.4)*.
(8) Performance of the plant change evaluation that demonstrates that changes in risk, defense-in-depth, and safety margins are acceptable *(see 4.4.6)*. Additional fire protection features or other alternatives shall be implemented if any one of these is unacceptable.
(9) Development of a monitoring program to monitor plant performance as it applies to fire risk. This program shall provide feedback for adjusting the fire protection program, as necessary *(see Section 4.6)*.
(10) For the resulting plant fire protection program, provision of documentation, assurance of the quality of the analyses, and maintenance of the configuration control of the resulting plant design and operation *(see Section 4.7)*.

4.2.1 Fundamental Fire Protection Program and Design Elements. The fundamental fire protection program and design elements shall include the fire protection features and systems described in Chapter 5.

4.2.2* Fire Hazards Identification. The fire area boundaries and fire hazards shall be identified.

4.2.3 Evaluating Performance Criteria. To determine whether plant design will satisfy the appropriate performance criteria, an analysis shall be performed on a fire area basis, given the potential fire exposures and damage thresholds, using either a deterministic or performance-based approach.

4.2.4 Performance Criteria. The performance criteria for nuclear safety, radioactive release, life safety, and property damage/business interruption covered by this standard are listed in Section 1.5 and shall be examined on a fire area basis.

4.2.5 Identification of Systems, Structures, and Components (SSCs). The SSCs required to achieve the selected performance criteria shall be identified on a fire area basis.

4.2.6* Deterministic Approach. Compliance with the deterministic requirements in Chapter 6 shall be an acceptable alternative to the performance-based approach and shall be considered to satisfy the performance criteria established in Section 1.5.

4.2.7* Existing Engineering Equivalency Evaluations.

4.2.7.1 When applying a deterministic approach, the user shall be permitted to demonstrate compliance with specific deterministic fire protection design requirements in Chapter 6 for existing configurations with an engineering equivalency evaluation.

4.2.7.2 These existing engineering evaluations shall clearly demonstrate an equivalent level of fire protection compared to the deterministic requirements.

4.2.8* Performance-Based Approach.

4.2.8.1 The performance-based approach to satisfy the nuclear safety, radiation release, life safety, and property damage/business interruption performance criteria shall require engineering analyses to evaluate whether the performance criteria are satisfied.

4.2.8.2 Engineering analyses shall be performed in accordance with Section 4.3.

4.2.9 Plant Change Evaluation. In the event of a change to a previously approved fire protection program element, a risk-informed plant change evaluation shall be performed and the results used as described in 4.4.6 to ensure that the public risk associated with fire-induced nuclear fuel damage accidents is low and that defense-in-depth and safety margins are maintained.

4.2.10 Monitoring Program. A monitoring program shall be established to assess the performance of the fire protection program in meeting the performance criteria established in this standard. *(See Section 4.6.)*

4.2.11 Documentation and Design Configuration Control. The fire protection program documentation shall be developed and maintained in such a manner that facility design and procedural changes that could affect the fire protection engineering analysis assumptions can be identified and analyzed. *(See Section 4.3.)*

4.3 Assumptions.

4.3.1 The following assumptions shall be made when performing a deterministic analysis for ensuring that the nuclear safety performance criteria are met:

(1) Independent failures (i.e., failures that are not a direct consequence of fire damage) of systems, equipment, instrumentation, controls, or power supplies relied upon to achieve the nuclear safety performance criteria do not occur before, during, or following the fire.
(2) Based on the assumption specified in 4.3.1(1), contrary to other nuclear power plant design basis events, a concurrent single active failure is not required to be postulated.
(3) No abnormal system transients, behavior, or design basis accidents precede the onset of the fire, nor do any of these events, which are not a direct consequence of fire damage, occur during or following the fire.

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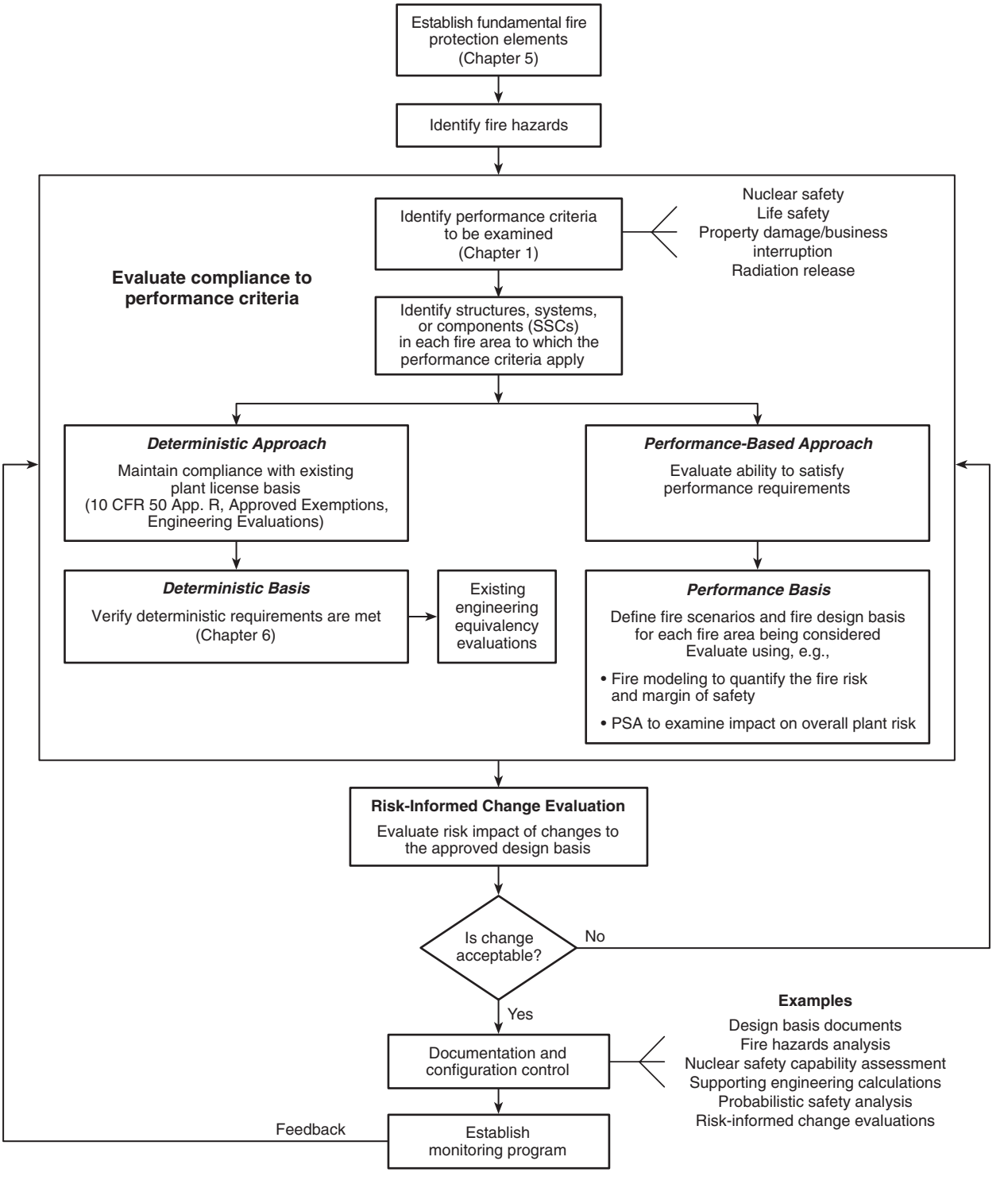

FIGURE 4.2 Methodology.

4.3.2 Information (e.g., equipment out of service, equipment failure unrelated to the fire, concurrent design basis events) are integral parts of a probabilistic safety assessment (PSA) and shall be considered when performance-based approaches are utilized.

4.4 Engineering Analyses. Engineering analysis shall be considered an acceptable means of evaluating a fire protection program against performance criteria.

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4.4.1 Engineering analyses shall be permitted to be qualitative or quantitative in accordance with Figure 4.4.1.

4.4.2 The effectiveness of the fire protection features shall be evaluated in relation to their ability to detect, control, suppress, and extinguish a fire and provide passive protection to achieve the performance criteria and not exceed the damage threshold defined in Section 4.4 for the plant area being analyzed.

4.4.3 Fire Modeling Calculations.

4.4.3.1 Application of Fire Modeling Calculations. The fire modeling process shall be permitted to be used to examine the impact of the different fire scenarios against the performance criteria under consideration.

4.4.3.2 Fire Models.

4.4.3.2.1 Acceptable Models. Only fire models that are acceptable to the authority having jurisdiction shall be used in fire modeling calculations.

4.4.3.2.2 Limitations of Use. Fire models shall be applied only within the limitations of that fire model. *(See Annex C.)*

4.4.3.2.3 Validation of Models. The fire models shall be verified and validated.

4.4.3.3 Fire Scenarios. When using fire modeling, a set of fire scenarios shall be defined for each plant area being modeled *(see Annex C)*.

4.4.3.3.1 The fire scenarios shall establish the conditions under which a proposed solution is expected to meet the performance criteria.

4.4.3.3.2 The fire scenarios specified in 4.4.3.3.1 shall become the fire protection design basis associated with the performance objective for that area.

4.4.3.3.3 The set of fire scenarios for each plant area shall include the following:

(1) Maximum expected fire scenarios
(2) Limiting fire scenario(s)

4.4.3.4 Defining the Fire Scenario. A fire scenario shall consider all operational conditions of the plant, including 100 percent power, cold shutdown, refueling modes of operation, and the following factors:

(1) *Combustible Materials.* The type, quantity, location, concentration, and combustion characteristics (e.g., ignition temperature, flash point, growth rate, heat release rate, radiant heat flux) of in situ and expected transient combustible materials shall be considered in defining the area fire scenarios.
(2) *Ignition Sources.* Ignition sources shall be considered as follows:
    (a) Potential in situ and transient ignition sources shall be considered for the plant area.
    (b) For fire modeling purposes, the combustibles shall be assumed to have become ignited by an ignition source.
(3) *Plant Area Configuration.* With respect to the configuration of the area, zone, or room configuration, plant construction surrounding the area and area geometry [e.g., (1) volume, ceiling height, floor area, and openings, (2) geometry between combustibles, ignition sources, and targets, and (3) surrounding barriers] shall be considered.
(4) *Fire Protection Systems and Features.* Those fire protection systems and features (i.e., fire protection suppression and detection systems, fire barriers, manual suppression capability) in the area that could mitigate the effects of the fire shall be evaluated.
(5) *Ventilation Effects.* Natural ventilation or forced ventilation effects (e.g., forced air, ventilation openings from doors and windows, ventilation-controlled fire versus fuel controlled fire) shall be evaluated.

4.4.4 Nuclear Safety Capability Assessment.

4.4.4.1 The purpose of this section is to define the methodology for performing a nuclear safety capability assessment.

4.4.4.2 The following steps shall be performed to determine structures, systems, and components that shall be evaluated:

(1) Identification of systems, equipment, and equipment location and their interrelationships necessary to achieve the nuclear safety performance criteria in Chapter 1
(2) Identification and location of cables necessary to achieve the nuclear safety performance criteria in Chapter 1
(3) Assessment of the ability to achieve the nuclear safety performance criteria given a fire in each fire area

4.4.4.3* The steps specified in 4.4.4.2(1) through 4.4.4.2(3) shall be performed to determine equipment and cables that shall be evaluated using either the deterministic or performance-based method in Chapter 6.

4.4.4.4 In addition to the requirements of 4.4.4.3, other performance-based or risk-informed methods acceptable to the authority having jurisdiction (AHJ) shall be permitted. *(See Annex B for special considerations for non-power operational modes.)*

4.4.4.5* Nuclear Safety Capability Systems and Equipment Selection. A comprehensive list of systems and equipment and their interrelationships to be analyzed for a fire event shall be developed.

4.4.4.5.1 The equipment list shall contain an inventory of those critical components required to achieve the nuclear safety performance criteria of Section 1.5.

4.4.4.5.2 Components required to achieve and maintain the nuclear safety functions and components whose fire-induced failure could prevent the operation or result in the maloperation of those components needed to meet the nuclear safety criteria shall be included.

4.4.4.5.3 Availability and reliability of equipment selected shall be evaluated.

4.4.4.6 Nuclear Safety Capability Circuit Analysis.

4.4.4.6.1* Circuits Required in Nuclear Safety Functions. Circuits required for the nuclear safety functions shall be identified.

4.4.4.6.1.1 Circuits required for nuclear safety functions shall include those that are required for operation, that could prevent the operation, or that result in the maloperation of the equipment identified in 4.4.4.5.

4.4.4.6.1.2* The evaluation shall consider fire-induced failure modes, such as hot shorts (external and internal), open circuits, and shorts to ground, to identify circuits that are required to support the operation of components required to achieve the nuclear safety performance criteria, including spurious operation and signals.

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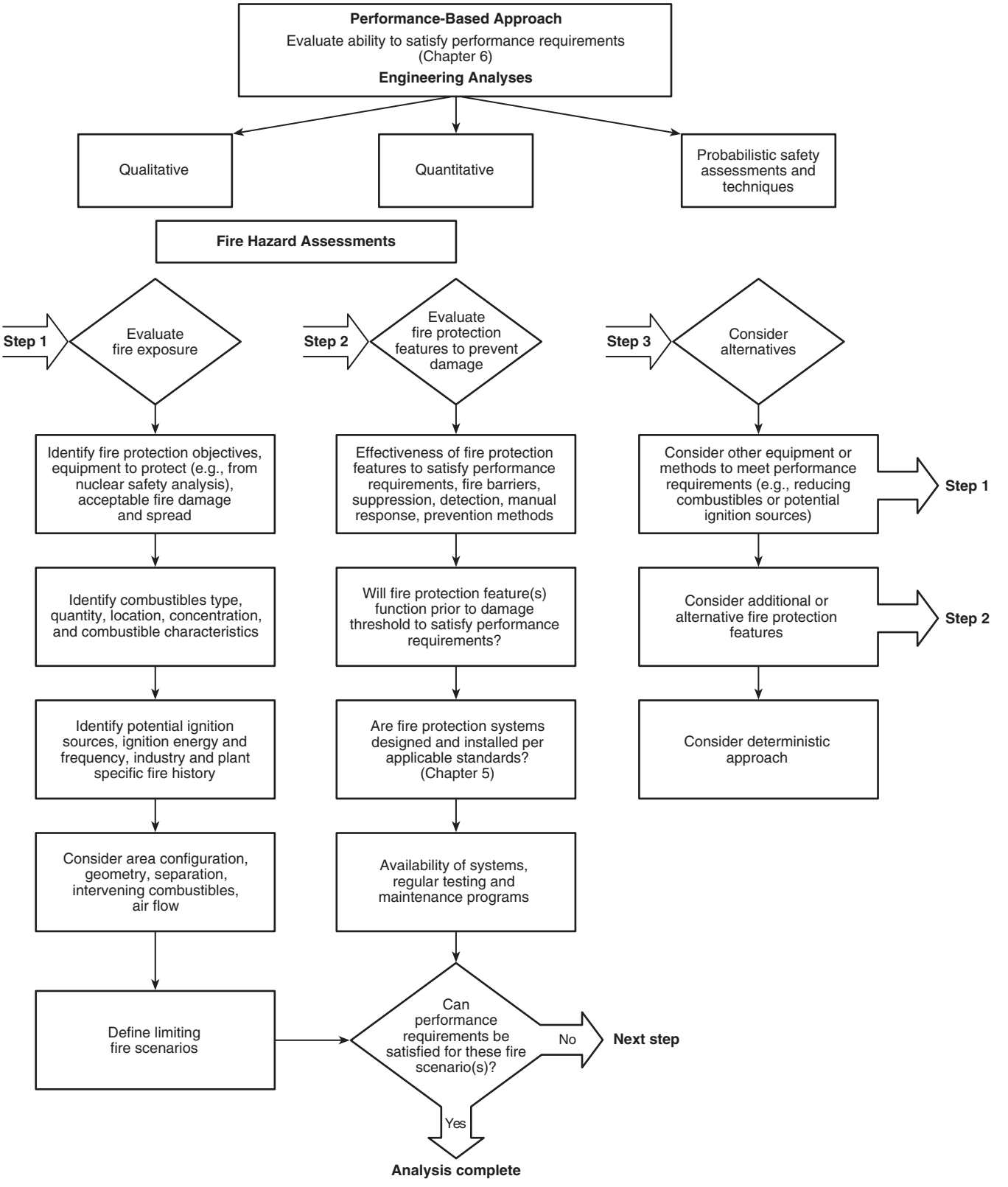

FIGURE 4.4.1 Engineering Analysis.

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4.4.4.6.2* Other Required Circuits. Other circuits that share common power supply and/or common enclosure with circuits required to achieve nuclear safety performance criteria shall be evaluated for their impact on the ability to achieve nuclear safety performance criteria.

4.4.4.6.2.1 Common Power Supply Circuits. Those circuits whose fire-induced failure could cause the loss of a power supply required to achieve the nuclear safety performance criteria shall be identified to protect against a situation that could occur if the upstream protection device (i.e., breaker or fuse) is not coordinated with the downstream protection device.

4.4.4.6.2.2 Common Enclosure Circuits. Those circuits that share enclosures with circuits required to achieve the nuclear safety performance criteria and whose fire-induced failure could cause the loss of the required components shall be identified. The concern is that the effects of a fire can extend outside of the immediate fire area due to fire-induced electrical faults on inadequately protected cables or via inadequately sealed fire area boundaries.

4.4.4.7* Nuclear Safety Equipment and Cable Location. Physical location of equipment and cables shall be identified.

4.4.4.8* Fire Area Assessment. An engineering analysis shall be performed for each fire area to determine the effects of fire and/or fire suppression activities on the ability to achieve the nuclear safety performance criteria of Section 1.5. *[See Chapter 4 for methods of achieving these performance criteria (performance-based or deterministic).]*

4.4.5* Fire Risk Evaluations. The PSA methods, tools, and data used to provide risk information for the performance-based evaluation of fire protection features *(see 6.2.5.2)* or provide risk information to the change analysis described in 4.4.4 shall conform with the requirements in 4.4.5.1 through 4.4.5.3.

4.4.5.1* The PSA evaluation shall use core damage frequency (CDF) and large early release frequency (LERF) as measures for risk.

4.4.5.2* The PSA evaluation shall address the risk contribution associated with all potentially risk-significant fire scenarios.

4.4.5.3* The PSA approach, methods, and data shall be acceptable to the AHJ, and the following criteria also shall apply:

(1) They shall be appropriate for the nature and scope of the change being evaluated.
(2) They shall be based on the as-built and as-operated and maintained plant.
(3) They shall reflect the operating experience at the plant.

4.4.6* Plant Change Evaluation. A plant change evaluation shall be performed to ensure that a change to a previously approved fire protection program element is acceptable.

4.4.6.1 The evaluation process shall consist of an integrated assessment of the acceptability of risk, defense-in-depth, and safety margins.

4.4.6.2 The impact of the proposed change shall be monitored *(see Section 4.6)*.

4.4.6.3* Risk Acceptance Criteria. The change in public health risk from any plant change shall be acceptable to the AHJ.

4.4.6.3.1 CDF and LERF shall be used to determine the acceptability of the change.

4.4.6.3.2 When more than one change is proposed, additional requirements shall apply.

4.4.6.3.3 If previous changes have increased risk but have met the acceptance criteria, the cumulative effect of those changes shall be evaluated.

4.4.6.3.4 If more than one plant change is combined into a group for the purposes of evaluating acceptable risk, the evaluation of each individual change shall be performed along with the evaluation of combined changes.

4.4.6.4* Defense-in-Depth.

4.4.6.4.1 The plant change evaluation shall ensure that the philosophy of defense-in-depth is maintained, relative to fire protection *(see Section 1.2)* and nuclear safety.

4.4.6.4.2 The deterministic approach for meeting the performance criteria shall be deemed to satisfy this defense-in-depth requirement.

4.4.6.5 Safety Margins.

4.4.6.5.1 The plant change evaluation shall ensure that safety margins are maintained.

4.4.6.5.2 The deterministic approach for meeting the performance criteria shall be deemed to satisfy the safety margins requirement in 4.4.6.5.1.

4.5* Evaluating the Damage Threshold.

4.5.1 When using fire modeling or when doing analysis in support of the performance-based approach, damage thresholds for important SSCs and limiting conditions for plant personnel shall be defined.

4.5.2 The following shall be considered with respect to the damage threshold(s):

(1) Thermal impact, which is the critical temperature and critical heat flux used for the evaluation of the potential for thermal damage of structures, systems, and components
(2) Smoke impact, which is the susceptibility of structures, systems, and components to smoke damage
(3) Fire suppressants impact, which is the susceptibility of structures, systems, components, and operations response to suppressant damage (due to discharge or rupture)
(4) Tenability, which is the effects of smoke and heat on personnel actions

4.6* Monitoring.

4.6.1 A monitoring program shall be established to ensure that the availability and reliability of the fire protection systems and features are maintained and to assess the performance of the fire protection program in meeting the performance criteria.

4.6.2 Monitoring shall ensure that the assumptions in the engineering analysis remain valid.

4.6.3 Availability, Reliability, and Performance Levels. Acceptable levels of availability, reliability, and performance shall be established.

4.6.4 Monitoring Availability, Reliability, and Performance.

4.6.4.1 Methods to monitor availability, reliability, and performance shall be established.

4.6.4.2 The methods shall take into account the plant operating experience and industry operating experience.

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4.6.5 Corrective Action.

4.6.5.1 If the established levels of availability, reliability, or performance are not met, corrective actions to return to the established levels shall be implemented.

4.6.5.2 Monitoring shall be continued to ensure that the corrective actions are effective.

4.7 Program Documentation, Configuration Control, and Quality.

4.7.1 Content.

4.7.1.1 General. The analyses performed to demonstrate compliance with this standard shall be documented for each nuclear power plant (NPP).

4.7.1.1.1 The intent of the documentation shall be to describe the assumptions and the results. The documentation shall provide a level of detail that will allow future review of the entire analysis.

4.7.1.1.2 Documentation shall be maintained for the life of the plant and be organized so that it can be checked for adequacy and accuracy either by an independent reviewer or by the AHJ.

4.7.1.2* Fire Protection Program Design Basis Document.

4.7.1.2.1 A fire protection program design basis document shall be established based on those documents, analyses, engineering evaluations, calculations, and so forth that define the fire protection design basis for the plant.

4.7.1.2.2 As a minimum, the document shall include fire hazards identification and nuclear safety capability assessment, on a fire area basis, for all fire areas that could affect the nuclear safety or radioactive release performance criteria defined in Chapter 1.

4.7.1.3* Supporting Documentation. Detailed information used to develop and support the principal document shall be referenced as separate documents if not included in the principal document.

4.7.2 Configuration Control.

4.7.2.1 Design Basis Document.

4.7.2.1.1 The design basis document shall be maintained up-to-date as a controlled document.

4.7.2.1.2 Changes affecting the design, operation, or maintenance of the plant shall be reviewed to determine if these changes impact the fire protection program documentation.

4.7.2.2 Supporting Documentation.

4.7.2.2.1 Detailed supporting information shall be retrievable records.

4.7.2.2.2 Records shall be revised as needed to maintain the principal documentation up-to-date.

4.7.3* Quality.

4.7.3.1 Review. Each analysis, calculation, or evaluation performed shall be independently reviewed.

4.7.3.2* Verification and Validation. Each calculational model or numerical method used shall be verified and validated through comparison with test results or comparison with other acceptable models.

4.7.3.3 Limitations of Use.

4.7.3.3.1 Acceptable engineering methods and numerical models shall be used for applications only to the extent these methods have been subject to verification and validation.

4.7.3.3.2 Acceptable engineering methods shall be applied only within the scope, limitations, and assumptions prescribed for each method.

4.7.3.4 Qualification of Users. Cognizant personnel who use and apply engineering analysis and numerical models (e.g., fire modeling techniques) shall be competent in that field and experienced in the application of these methods as they relate to nuclear power plants, nuclear power plant fire protection, and power plant operations.

4.7.3.5* Uncertainty Analysis. An uncertainty analysis shall be performed to provide assurance that the performance criteria have been met.

Chapter 5 Fundamental Fire Protection Program and Design Elements

5.1* General. This chapter shall apply to the fundamental elements of the fire protection program and specify the minimum design requirements for fire protection systems and features.

5.1.1 The fire protection program elements and minimum design requirements shall not be subject to the performance-based methods permitted elsewhere in this standard, unless approved by the AHJ.

5.1.2 Previously approved alternatives from the fundamental protection program attributes of this chapter by the AHJ take precedence over the requirements contained herein.

5.2 Fire Protection Plan.

5.2.1 Intent. A site-wide fire protection plan shall be established.

5.2.2 The fire protection plan shall document management policy and program direction and shall define the responsibilities of those individuals responsible for the plan's implementation.

5.2.3 The requirements of this section shall be used to establish the criteria for an integrated combination of components, procedures, and personnel to implement all fire protection program activities.

5.2.4* Management Policy Direction and Responsibility. A policy document shall be prepared that defines management authority and responsibilities and establishes the general policy for the site fire protection program.

5.2.4.1* The policy document shall designate the senior management position with immediate authority and responsibility for the fire protection program.

5.2.4.2* The policy document shall designate a position responsible for the daily administration and coordination of the fire protection program and its implementation.

5.2.4.3* The policy document shall include the following:

(1) It shall define the fire protection interfaces with other organizations and assign responsibilities for the coordination of activities.

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(2) It shall identify the various plant positions having the authority for implementing the various areas of the fire protection program.
(3) It shall identify the appropriate AHJ for the various areas of the fire protection program.

5.2.5* Procedures.

5.2.5.1 Procedures shall be established for implementation of the fire protection program.

5.2.5.2 In addition to procedures that could be required by other sections of this standard, the procedures for accomplishing the following shall be established:

(1)*Inspection, testing, and maintenance for fire protection systems and features credited by the fire protection program
(2)*Compensatory actions to be implemented when fire protection systems and other systems credited by the fire protection program and this standard cannot perform their intended function and limits on impairment duration
(3)*Reviews of fire protection program–related performance and trends
(4) Reviews of physical plant modifications and procedure changes for impact on the fire protection program
(5) Long-term maintenance and configuration of the fire protection program
(6) Emergency response procedures for the plant industrial fire brigade

5.3 Prevention. A fire prevention program with the goal of preventing a fire from starting shall be established, documented, and implemented as part of the fire protection program.

5.3.1 The two basic components of the fire prevention program shall consist of both of the following:

(1) Prevention of fires and fire spread by controls on operational activities
(2) Design controls that restrict the use of combustible materials

5.3.2 The design control requirements listed in the remainder of this section shall be provided as described.

5.3.3 Fire Prevention for Operational Activities.

5.3.3.1 The fire prevention program activities shall consist of elements to address the control of ignition sources and the use of transient combustible materials during all aspects of plant operations.

5.3.3.2 The fire prevention program shall focus on the human and programmatic elements necessary to prevent fires from starting or, in the event that a fire starts, to keep the fire as small as possible.

5.3.3.3 General Fire Prevention Activities. The fire prevention activities shall include but shall not be limited to the following program elements:

(1) Training on fire safety information for all employees and contractors, including, as a minimum, familiarization with plant fire prevention procedures, fire reporting, and plant emergency alarms
(2)*Documented plant inspections, including provisions for corrective actions for conditions where unanalyzed fire hazards are identified
(3)*Administrative controls addressing the review of plant modifications and maintenance to ensure that both fire hazards and the impact on plant fire protection systems and features are minimized

5.3.3.4* Control of Combustible Materials.

5.3.3.4.1 Procedures for the control of general housekeeping practices and the control of transient combustibles shall be developed and implemented.

5.3.3.4.2 The procedures shall include but not be limited to the following program elements:

(1)*Wood used within the power block shall be listed pressure-impregnated or coated with a listed fire-retardant application unless otherwise permitted by 5.3.3.4.2(2).
(2) Cribbing timbers 6 in. × 6 in. (15.2 cm × 15.2 cm) or larger shall not be required to be fire retardant–treated.
(3) Plastic sheeting materials used in the power block shall be fire-retardant types that have passed NFPA 701 large-scale tests or equivalent.
(4)*Waste, debris, scrap, packing materials, or other combustibles shall be removed from an area immediately following the completion of work or at the end of the shift, whichever comes first.
(5)*Combustible storage or staging areas shall be designated, and limits shall be established on the types and quantities of stored materials.
(6)*Controls on use and storage of flammable and combustible liquids shall be in accordance with NFPA 30 or other applicable NFPA standards.
(7) Controls on use and storage of flammable gases shall be in accordance with applicable NFPA standards.

5.3.3.5 Control of Ignition Sources.

5.3.3.5.1* A hot work safety procedure shall be developed, implemented, and periodically updated as necessary in accordance with NFPA 51B and NFPA 241.

5.3.3.5.2 Smoking and other possible sources of ignition shall be restricted to designated and supervised safe areas of the plant.

5.3.3.5.3 Open flames or combustion-generated smoke shall not be permitted for leak or air flow testing.

5.3.3.5.4* Plant administrative procedure shall control the use of portable electrical heaters in the plant.

5.3.3.5.5 Portable fuel-fired heaters shall not be permitted in plant areas containing equipment important to nuclear safety or where there is a potential for radiological releases resulting from a fire.

5.3.4 Structural. Walls, floors, and components required to maintain structural integrity shall be of noncombustible construction, as defined in NFPA 220.

5.3.5 Interior Finishes.

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

5.3.5.2 Interior floor finishes shall be in accordance with NFPA *101* requirements for Class I interior floor finishes.

5.3.6 Insulation Materials. Thermal insulation materials, radiation shielding materials, ventilation duct materials, and soundproofing materials shall be noncombustible or limited combustible.

5.3.7 Electrical.

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

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5.3.7.2 Only metal tray and metal conduits shall be used for exposed electrical raceways.

5.3.7.3* Electric cable construction shall comply with a flame propagation test acceptable to the AHJ. Alternatively, a flame-retardant coating shall be applied to the electric cables, or an automatic fixed fire suppression system shall be installed to provide an equivalent level of protection acceptable to the AHJ.

5.3.7.3.1 Existing cable in place prior to the adoption of this standard shall be permitted to remain as is.

5.3.8 Roofs.

5.3.8.1 Metal roof deck construction shall be designed and installed so the roofing system will not sustain a self-propagating fire on the underside of the deck when the deck is heated by a fire inside the building.

5.3.8.2 Roof coverings shall be Class A as determined by tests described in NFPA 256.

5.3.9 Bulk Flammable Gas Storage. Bulk compressed or cryogenic flammable gas storage shall not be permitted inside structures housing systems, equipment, or components important to nuclear safety.

5.3.9.1 Storage of flammable gas shall be located outdoors or in separate detached buildings, so that a fire or explosion will not adversely impact systems, equipment, or components important to nuclear safety.

5.3.9.2 NFPA 55 shall be followed for hydrogen storage.

5.3.9.3 Outdoor high-pressure flammable gas storage containers shall be located so that the long axis is not pointed at buildings.

5.3.9.4 Flammable gas storage cylinders not required for normal operation shall be isolated from the system.

5.3.10 Bulk Storage of Flammable and Combustible Liquids.

5.3.10.1 Bulk storage of flammable and combustible liquids shall not be permitted inside structures containing systems, equipment, or components important to nuclear safety.

5.3.10.2 As a minimum, storage and use shall comply with NFPA 30.

5.3.11* Transformers. Where provided, transformer oil collection basins and drain paths shall be inspected to ensure that they are free of debris and capable of performing their design function.

5.3.12* Hot Pipes and Surfaces.

5.3.12.1 Combustible liquids, including high flash point lubricating oils, shall be kept from coming in contact with hot pipes and surfaces, including insulated pipes and surfaces.

5.3.12.2 Administrative controls shall require the prompt cleanup of oil on insulation.

5.3.13* Reactor Coolant Pumps. For facilities with non-inerted containments, reactor coolant pumps with an external lubrication system shall be provided with an oil collection system.

5.3.13.1 The oil collection system shall be designed and installed such that leakage from the oil system is contained for off-normal conditions such as accident conditions or earthquakes.

5.3.13.2 All of the following criteria shall apply to the oil collection system:

(1) The oil collection system for each reactor coolant pump shall be capable of collecting lubricating oil from all potential pressurized and nonpressurized leakage sites in each reactor coolant pump oil system.
(2) Leakage shall be collected and drained to a vented closed container that can hold the inventory of the reactor coolant pump lubricating oil system.
(3) A flame arrester shall be required in the vent if the flash point characteristics of the oil present the hazard of a fire flashback.
(4) The leakage points on a reactor coolant pump motor that are to be protected shall include but not be limited to the following where such features exist:
    (a) Lift pump and piping
    (b) Overflow lines
    (c) Oil cooler
    (d) Oil fill and drain lines and plugs
    (e) Flanged connections on oil lines
    (f) Oil reservoirs
(5) The collection basin drain line to the collection tank shall be large enough to accommodate the largest potential oil leak such that oil leakage does not overflow the basin.

5.4 Industrial Fire Brigade.

5.4.1 On-Site Fire-Fighting Capability. All of the following requirements shall apply to on-site fire fighting.

(1) A fully staffed, trained, and equipped fire-fighting force shall be available at all times to control and extinguish all fires on site.
(2) The fire-fighting force shall have a minimum complement of five persons on duty and shall conform with the following NFPA standards as applicable:
    (a) NFPA 600 (interior structural fire fighting)
    (b) NFPA 1500
    (c) NFPA 1582
(3)*Industrial fire brigade members shall have no other assigned normal plant duties that would prevent response to a fire or other emergency as required.
(4) During every shift, the brigade leader and at least two brigade members shall have sufficient training and knowledge of nuclear safety systems to understand the effects of fire and fire suppressants on nuclear safety performance criteria unless otherwise permitted by 5.4.1(5).
(5) Training and knowledge as specified by 5.4.1(4) shall be permitted to be provided by an operations advisor dedicated to industrial fire brigade support.
(6)*The industrial fire brigade shall be notified upon verification of a fire.
(7) Each industrial fire brigade member shall pass an annual physical examination to determine that he or she can perform the strenuous activity required during manual fire-fighting operations.
(8) The physical examination specified in 5.4.1(7) shall determine the ability of each member to use respiratory protection equipment.

5.4.2* Pre-Fire Plans. Current and detailed pre-fire plans shall be available to the industrial fire brigade for all areas in which a fire could jeopardize the ability to meet the performance criteria described in Section 1.5.

5.4.2.1* The plans shall detail the fire area configuration and fire hazards to be encountered in the fire area, along with any

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nuclear safety components and fire protection systems and features that are present.

5.4.2.2 Pre-fire plans shall be reviewed and updated.

5.4.2.3* Pre-fire plans shall be available in the control room and made available to the plant industrial fire brigade.

5.4.2.4* Pre-fire plans shall address coordination with other plant groups during fire emergencies.

5.4.3 Training and Drills. Industrial fire brigade members and other plant personnel who would respond to a fire in conjunction with the brigade shall be provided with training commensurate with their emergency responsibilities.

5.4.3.1 Plant Industrial Fire Brigade Training. All of the following requirements shall apply to plant industrial fire brigade training:

(1) Plant industrial fire brigade members shall receive training consistent with the requirements contained in NFPA 600 or NFPA 1500, as appropriate.
(2) Industrial fire brigade members shall be given quarterly training and practice in fire fighting, including 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.
(3) A written program shall detail the industrial fire brigade training program.
(4) Written records that include but are not limited to the following shall be maintained for each industrial fire brigade member:
    (a) Initial industrial fire brigade classroom and hands-on training
    (b) Refresher training
    (c) Special training schools attended
    (d) Drill attendance records
(5) Leadership training for industrial fire brigades shall be maintained for each industrial fire brigade member.

5.4.3.2 Training for Nonindustrial Fire Brigade Personnel. Plant personnel who respond with the industrial fire brigade shall be trained as to their responsibilities, potential hazards to be encountered, and interfacing with the industrial fire brigade.

5.4.3.3* Drills. All of the following requirements shall apply to fire brigade drills:

(1) Drills shall be conducted quarterly for each shift to test the response capability of the industrial fire brigade.
(2) Drills shall be developed to accomplish the following:
    (a) To test and challenge industrial fire brigade response, including brigade performance as a team, proper use of equipment, effective use of pre-fire plans, and coordination with other groups
    (b) To evaluate the industrial fire brigade's abilities to react, respond, and demonstrate proper fire-fighting techniques to control and extinguish the fire and smoke conditions being simulated by the drill scenario
(3) Industrial fire brigade drills shall be conducted in various plant areas, especially in those areas identified to be essential to plant operation and to contain significant fire hazards.
(4) Drill records shall be maintained that detail the drill scenario, industrial fire brigade member response, and ability of the industrial fire brigade to perform as a team.
(5) A critique shall be held and documented after each drill.

5.4.4 Fire-Fighting Equipment.

5.4.4.1 Protective clothing, respiratory protective equipment, radiation monitoring equipment, personal dosimeters, and fire suppression equipment such as hoses, nozzles, fire extinguishers, and other needed equipment shall be provided for the industrial fire brigade.

5.4.4.2 The equipment specified in 5.4.4.1 shall conform with the applicable NFPA standards.

5.4.5 Off-Site Fire Department Interface.

5.4.5.1 Mutual Aid Agreement. Off-site fire authorities shall be offered a plan for their interface during fires and related emergencies on site.

5.4.5.2* Site-Specific Training. Fire fighters from the off-site fire authorities who are expected to respond to a fire at the plant shall be offered site-specific training and shall be invited to participate in a drill at least annually.

5.4.5.3* Security and Radiation Protection. Plant security and radiation protection plans shall address off-site fire authority response.

5.4.6* Communications. An effective emergency communications capability shall be provided for the industrial fire brigade.

5.5 Water Supply.

5.5.1 A fire protection water supply of reliability, quantity, and duration shall be provided by one of the two following methods:

(1) A fire protection water supply of not less than two separate 300,000 gal (1,135,500 L) supplies shall be provided.
(2) The 2-hour fire flow rate for 2 hours shall be calculated, and the following criteria shall be met:
    (a) The flow rate shall be based on 500 gpm (1892.5 L/min) for manual hose streams plus the largest design demand of any sprinkler or fixed water spray system(s) in the power block as determined in accordance with NFPA 13 or NFPA 15.
    (b) 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.

5.5.2* The water tanks shall be interconnected such that fire pumps can take suction from either or both.

5.5.2.1 A failure in one tank or its piping shall not allow both tanks to drain.

5.5.2.2 The tanks shall be designed in accordance with NFPA 22.

5.5.2.3 Water storage tanks shall not be required when fire pumps are able to take suction from a large body of water (such as a lake), provided each fire pump has its own suction and both suctions and pumps are adequately separated.

5.5.2.4 Cooling tower basins shall be an acceptable water source for fire pumps when the volume is sufficient for both purposes and water quality is consistent with the demands of the fire service.

5.5.3* At least two 100 percent capacity fire pumps, designed and installed in accordance with NFPA 20, shall be provided to ensure that 100 percent of the required flow rate and pressure are available assuming failure of the largest pump or pump power source.

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5.5.4 At least one diesel engine–driven fire pump or two more seismic Category I Class IE electric motor–driven fire pumps connected to redundant Class IE emergency power buses capable of providing 100 percent of the required flow rate and pressure shall be provided.

5.5.5 Each pump and its driver and controls shall be separated from the remaining fire pumps and from the rest of the plant by rated fire barriers.

5.5.6 Fire pumps shall be provided with automatic start and manual stop only.

5.5.7 Individual fire pump connections to the yard fire main loop shall be provided and separated with sectionalizing valves between connections.

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

5.5.9 Means shall be provided to notify the control room or other constantly attended location of operation of fire pumps.

5.5.10 An underground yard fire main loop designed and installed in accordance with NFPA 24 shall be installed to furnish anticipated water requirements.

5.5.11 Means shall be provided to isolate portions of the yard fire main loop for maintenance or repair without simultaneously shutting off the supply to both fixed fire suppression systems and fire hose stations provided for manual backup.

5.5.12 Sprinkler systems and manual hose station standpipes shall be connected to the plant fire protection water main so that a single active failure or a crack to the water supply piping to these systems can be isolated so as not to impair both the primary and backup fire suppression systems.

5.5.13 Threads compatible with those used by local fire departments shall be provided on all hydrants, hose couplings, and standpipe risers unless otherwise provided by 5.5.14.

5.5.14 Fire departments shall be permitted to be provided with adapters that allow interconnection between plant equipment and the fire department equipment if training and procedures are provided.

5.5.15 Headers fed from each end shall be permitted inside buildings to supply both sprinkler and standpipe systems, provided that steel piping and fittings meeting the requirements of ASME B31.1 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.

5.5.16 Where provided, the headers specified in 5.5.15 shall be considered an extension of the yard main system.

5.5.17 Each sprinkler and standpipe system shall be equipped with an outside screw and yoke (OS&Y) gate valve or other approved shutoff valve.

5.5.18* All fire protection water supply and fire suppression system control valves shall be under an inspection program and shall be supervised by one of the following methods:

(1) Electrical supervision with audible and visual signals in the main control room or other suitable, constantly attended location
(2) Locking valves in their normal position with keys made available only to authorized personnel
(3) Sealing valves in their normal positions with this option permitted only where valves are located within fenced areas or under the direct control of the owner or operator

5.5.19 Hydrants shall be installed every 250 ft (76 m) on the yard main system, and the following also shall apply:

(1) A hose house equipped with hose and combination nozzle and other auxiliary equipment specified in NFPA 24 shall be provided at intervals of not more than 1000 ft (305 m) along the yard main system.
(2) Mobile means of providing hose and associated equipment, such as hose carts or trucks, shall be permitted in lieu of hose houses.
(3) Where provided, the mobile equipment specified in 5.5.19(2) shall be equivalent to the equipment supplied by three hose houses.

5.5.20* The fire protection water supply system shall be dedicated for fire protection use only unless otherwise permitted by the following:

(1) Fire protection water supply systems shall be permitted to be used to provide backup to nuclear safety systems, provided that the fire protection water supply systems are designed and maintained to deliver the combined fire and nuclear safety flow demands for the duration specified by the applicable analysis.
(2) Fire protection water storage shall be permitted to be provided by plant systems serving other functions, provided that the storage has a dedicated capacity capable of providing the maximum fire protection demand for the specified duration as determined in this section.

5.6 Standpipe and Hose Stations.

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

5.6.2 Provision of both of the following shall be ensured:

(1) Water flow rate and nozzle pressure for all hose stations
(2) Hose station pressure reducers where necessary for the safety of plant industrial fire brigade members and off-site fire department personnel

5.6.3 The type of hose nozzle to be supplied to each power block area shall be based on the area fire hazards.

5.6.3.1 The usual combination spray/straight stream nozzle shall not be used in areas where the straight stream can cause unacceptable damage or present an electrical hazard to fire-fighting personnel.

5.6.3.2 Listed electrically safe fixed fog nozzles shall be provided at locations where high-voltage shock hazards exist.

5.6.3.3 All hose nozzles shall have shutoff capability and be able to control water flow from full open to full closed.

5.6.4 Provisions shall be made to supply water at least to standpipes and hose stations for manual fire suppression in all areas containing systems and components needed to perform the nuclear safety functions in the event of a safe shutdown earthquake (SSE) unless otherwise permitted by 5.6.5.

5.6.4.1 For existing plants that are not capable of meeting the requirement of 5.6.4, provisions to restore a water supply and distribution system for manual fire-fighting purposes shall be made and the following criteria shall be met, as approved by the AHJ:

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