NFPA 803
Standard for Fire Protection for Light Water Nuclear Power Plants

1998 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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Fire Protection for Light Water Nuclear Power Plants

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This edition of NFPA 803, *Standard for Fire Protection for Light Water Nuclear Power 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 Fall Meeting held November 17–19, 1997, in Kansas City, MO. It was issued by the Standards Council on January 16, 1998, with an effective date of February 6, 1998, and supersedes all previous editions.

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.

This edition of NFPA 803 was approved as an American National Standard on February 6, 1998.

Origin and Development of NFPA 803

The Committee on Atomic Energy was organized in 1953 for the purpose of providing guidance on practices necessary for fire safety in facilities handling radioactive materials. A *Recommended Fire Protection Practice for Nuclear Reactors*, NFPA 802, was developed and officially adopted in 1960. Following a serious fire in 1975 at the Brown's Ferry Plant of the TVA, the Nuclear Regulatory Commission expressed the need for a fire protection standard specifically covering nuclear power plants. The committee started work on the preparation of this document early in 1976, and its efforts resulted in the first edition, which was issued in 1978.

Changes in the 1983 edition included a more precise title for the document as well as a complete revision of the chapter on fire alarm systems. The 1988 edition brought the standard into conformance with the NFPA *Manual of Style* and included several editorial changes to better explain various sections. The 1993 edition incorporated a variety of changes into the document.

The 1998 edition includes a new section on the equivalency concept. A new section on inspection, testing, and maintenance of fire protection systems that introduces the concept of a performance-based option has also been added.

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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.

Contents

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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.

Information on referenced publications can be found in Chapter 18 and Appendix B.

Chapter 1 Introduction

1-1* Scope. This standard covers the protection of light water nuclear power plants from the consequences of fire, including safety to life of on-site personnel, protection of property, and continuity of production. Nuclear safety is provided for in other documents such as the regulations published by the Nuclear Regulatory Commission (NRC).

1-2 Purpose. This standard is prepared for the use and guidance of those charged with the design, construction, operation, and protection of light water nuclear power plants. This standard covers those requirements essential to ensure that the consequences of fire will have minimum impact on the safety of construction and operating personnel, the physical integrity of plant components, and the continuity of plant operations. Additional emphasis is on requirements dictated by the need to protect the lives of constructors and operators from the consequences of fire and to conform to the best fire protection engineering practices.

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 as alternatives to those prescribed by this standard, provided that technical documentation is submitted to the authority having jurisdiction to demonstrate equivalency, and the system, method, or device is approved for the intended purpose.

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.

Approved.* Acceptable to the authority having jurisdiction.

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

Combustible. Any material that, in the form in which it is used and under the conditions anticipated, will ignite and burn.

Combustible Liquid.* A liquid having a flash point at or above 100°F (37.8°C).

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

Fire Barrier. Those components of construction (walls, floors, or floor/ceiling assemblies and their supports, including beams, joists, columns, penetration seals or closures, fire doors, and fire dampers) that are rated by approval laboratories in hours of resistance to fire and are used to prevent the spread of fire.

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

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*.

Fire Loading. The amount of combustibles present in a given situation, expressed in Btu per square foot.

Fire Prevention. Measures directed towards avoiding the inception of fire.

Fire Protection. Methods of providing for fire control or fire extinguishment.

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

Fire-Rated Penetration. An opening in a fire barrier for the passage of pipe, cable, duct, and so forth, that has been sealed so as not to reduce the integrity of the fire barrier.

Fire Resistance Rating. The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*.

Fire Zone. Subdivisions of fire areas in which fire detection and/or suppression systems provide alarm information indicating the location of fire at a central fire control center.

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*.

Flammable Liquid. Any liquid having a flash point below 100°F (37.8°C) and having a vapor pressure not exceeding 40 psi (276 kPa) absolute pressure at 100°F (37.8°C).

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.

Limited Combustible.* A building construction 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 $^1/_8$ in. (3.2 mm) that has a flame spread rating not greater than 50, or other 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.

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 identified standards or has been tested and found suitable for a specified purpose.

Noncombustible Material. A material that, in the form in which it is used and under the conditions anticipated, will not ignite, support combustion, burn, or release flammable vapors when subjected to fire or heat. Materials reported as noncombustible, when tested in accordance with ASTM E 136, *Test for Behavior of Materials in a Vertical Tube Furnace at 750°C*, shall be considered noncombustible materials.

Shall. Indicates a mandatory requirement.

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

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, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

1-5 Introduction and Special Problems Relating to the Protection of Light Water Nuclear Electric Generating Stations.

1-5.1 General Introduction. Fire protection is both an art and a science. Perfection and practice in this art is the objective, with fire prevention being the ultimate goal. Fire prevention in the absolute sense is only possible where there is no combustible material to fuel a fire. The presence of combustible material creates a fire potential, no matter how slight. As a first priority, fire prevention must regard, the presence of any combustible material as a variable.

The total elimination of combustible material is seldom possible; therefore, fire protection requires additional measures to limit the consequences of fire.

A defense-in-depth philosophy of fire prevention, control, and extinguishment shall be adopted and implemented to minimize and mitigate the effects of fire and reduce hazards to personnel and property damage to acceptable minimums.

A well-balanced fire protection program includes prevention, detection, extinguishment of fires, safety to life, and preservation of property. The protection of the environment and of the public against nuclear hazards takes priority over that of the plant itself and is addressed by the appropriate regulatory agencies. However, the size of nuclear power plants makes the economic impact of a forced outage such that protection measures must be extended to include provisions to ensure their continued operation.

1-5.2 Special Considerations in Fire Protection Encountered at Light Water Nuclear Power Plants. Consideration of the need for nuclear safety results in several areas of fire protection emphasis unique to the nuclear electric generating station *(see Appendix C)*. For example,

(a) Reactor shutdown systems
(b) Cooling system integrity
(c) Filtering system integrity
(d) Ventilating system integrity

1-5.3 Defense-in-Depth.

1-5.3.1 Light water nuclear power plants use the concept of defense-in-depth to achieve the high degree of safety required in the nuclear safety systems of the plant. This concept shall be extended to fire protection for the remaining areas of the plant.

1-5.3.2* With respect to the fire protection program, the defense-in-depth principle is aimed at achieving an adequate balance in the following:

(a) Preventing fires from starting
(b) Detecting fires quickly and suppressing those fires that occur, thereby limiting damage
(c) Designing the plant to limit the consequences of fire

1-5.4 Fire Protection Management Program. The fire protection program for a nuclear power plant shall cover design features, personnel, procedures, plans, and equipment. Senior management participation in this program shall begin with early design concepts and plant layout and continue through plant operation. In order to effectively develop and conduct this program, a fire protection manager shall be appointed at the conceptual stage of the project. The manager shall be selected on the basis of education, experience, and advancement as an industrial fire protection engineer. The manager shall establish liaison with all internal departments, with all authorities having jurisdiction, and with the public fire department.

1-5.5 Inspection, Testing, and Maintenance of Fire Protection Systems.

1-5.5.1 Fire Protection Systems. Fire protection systems designed and installed in accordance with Chapters 9, 10, 11, 12, and 13 shall be considered as meeting the objectives of this standard.

1-5.5.2 Equivalency. Nothing in this chapter is intended to prevent the use of calculation methods, test methods, systems, methods, or devices of superior strength, fire resistance, effectiveness, durability, and safety as alternatives to those required by this standard, provided that technical documentation is submitted to the authority having jurisdiction to demonstrate equivalency, and the system, method, or device is approved for the intended purpose.

1-5.5.3 Prescriptive-Based Option. Fire protection systems designed and installed in accordance with Chapters 9, 10, 11, 12, and 13 shall be inspected, tested, and maintained in accordance with the referenced publications in Chapter 18.

1-5.5.4 Performance-Based Option. Fire protection systems designed and installed in accordance with Chapters 9, 10, 11, 12, and 13 shall be permitted to be inspected, tested, and maintained based on a performance-based program accepted by the authority having jurisdiction.

1-5.5.5 Performance-Based Program. Performance-based programs for fire protection system inspection, testing, and maintenance shall be approved by the authority having jurisdiction. Technical justification for inspection, testing, and maintenance intervals shall be provided. The performance goal for operability is to provide reasonable assurance that the fire protection system or feature will perform its intended function on demand. This shall include historical data acceptable to the authority having jurisdiction. Plant-specific failure rate data shall be reviewed on a case-by-case basis to determine whether extensions are warranted.

1-6 Units of Measurement. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The liter, which is a unit outside of but recognized by SI, is commonly used in international fire protection. If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated is to be regarded as the requirement. A given equivalent value can be approximate.

Chapter 2 Functional Subdivisions of the Plant Layout

2-1* General. Safety to the lives of on-site personnel, protection of property, and continuity of power production as affected by the possibility of fires shall be given appropriate consideration in the general arrangement of the nuclear power plant. For the purposes of fire hazard analysis, the plant component facilities shall be divided into primary facilities, secondary facilities, and support facilities as follows *(see Figure 2-1)*.

(a) ***Typical Primary Facilities***

Reactor Building. Houses the reactor within a containment structure and its integral or freestanding shield.

Reactor Auxiliary Building. Contains reactor auxiliary and emergency core cooling system (ECCS) equipment.

Control Building. Houses the main and auxiliary control panels, emergency switchgear, and batteries.

Turbine Building. Houses the turbine generator and turbine generator auxiliaries.

Steam Generator Building. Houses the steam generator.

Intake Pumping Station. Houses the condenser circulating water makeup pumps, the raw service water and fire protection pumps, and all necessary valves and strainers for these systems.

Electrical Switchyard. Encompasses the electrical transmission system coming into the site and leaving the site.

Emergency Power Generation Facility. Provides on-site emergency power in the event of an off-site power failure.

Emergency Service Water Pumping Station. Houses the emergency service water pumps and all necessary valves, strainers, and electrical switchgear for these systems.

Condenser Circulating Water Pumping Station. Houses the condenser circulating water pumps, pump isolation valves, pump suction and discharge conduits, and associated electrical equipment.

Electrical Control and Communications Building. Houses the switchyard relays and terminal communications equipment and can act as a control center for the switchyard up until the time the main control room becomes operational.

Main Heat Rejection System. Includes cooling towers and facilities associated with spray ponds and canals.

Station Transformers. Provide auxiliary power to the plant or transmit power from the plant.

(b) ***Typical Secondary Facilities***

Fuel Building. Inclusion of primary equipment in this building would require upgrading of the affected portions of the building to primary facility status.

Radwaste Building. Houses the equipment for processing radioactive waste from the plant.

Makeup Water Treatment Plant. Produces high-purity water before use in the reactor or its support systems.

Condenser Circulating Water Treatment Building. Houses the plant and condenser circulating water biocide treatment system.

Demineralizer Regeneration Building. Contains facilities for regeneration and cleaning of resins from the plant condensate polishing system.

(c) ***Typical Support Facilities***

Office Building. Houses the offices for the plant's administrative employees and contains plant records.

Service Building. Encompasses the guard house, main gate, and office space for the plant's security force.

Auxiliary Boiler Building. Contains boilers for providing heating steam and steam to operate plant auxiliary equipment during the time that the nuclear steam supply is not available.

2-2 Reactor, Fuel, and Auxiliary Life Safety. For these three types of facilities, safety to the lives of on-site construction and operating personnel and loss of property shall be given consideration as specified in Chapter 17 and elsewhere in this standard.

2-3 Cost Benefit. For primary and secondary facilities, the cost of lost revenue and replacement power in addition to property loss shall be factored into the fire hazard analysis for determining the cost/benefit ratio for selecting the appropriate fire protection systems.

2-4* Fire Hazard Analysis. A fire hazard analysis shall be developed that will define the fire hazards that can exist and describe the loss-limiting criteria to be used in the design of the facility. The fire hazard analysis shall take into consideration the basic data of the plant, such as the functional subdivision of the facility, the controlled zones that have limited access, and the general plant layout of equipment or systems to develop the fire zone and the ratings of fire barriers.

Chapter 3 Inventory of Flammable and Combustible Materials

3-1 Combustible Materials. Combustible materials in both large and small concentrations will be present in nuclear power plants, as in most other industrial plants, and it shall be assumed that outbreaks of fire occur for a variety of reasons.

3-2 Fire Loading. For the purpose of assessing the fire loading, an inventory of all flammable and combustible materials shall be made for each fire area. This inventory shall identify the location, type, quantity, and form of the materials. The materials shall be classified as follows:

(a) *Flammable and Combustible Materials.* Typical examples of flammable and combustible materials found in a nuclear power plant are as follows:

1. Conventional fuels for emergency power units, auxiliary boilers, and so forth
2. Lubricants and hydraulic oil
3. Insulating materials (thermal and electric)

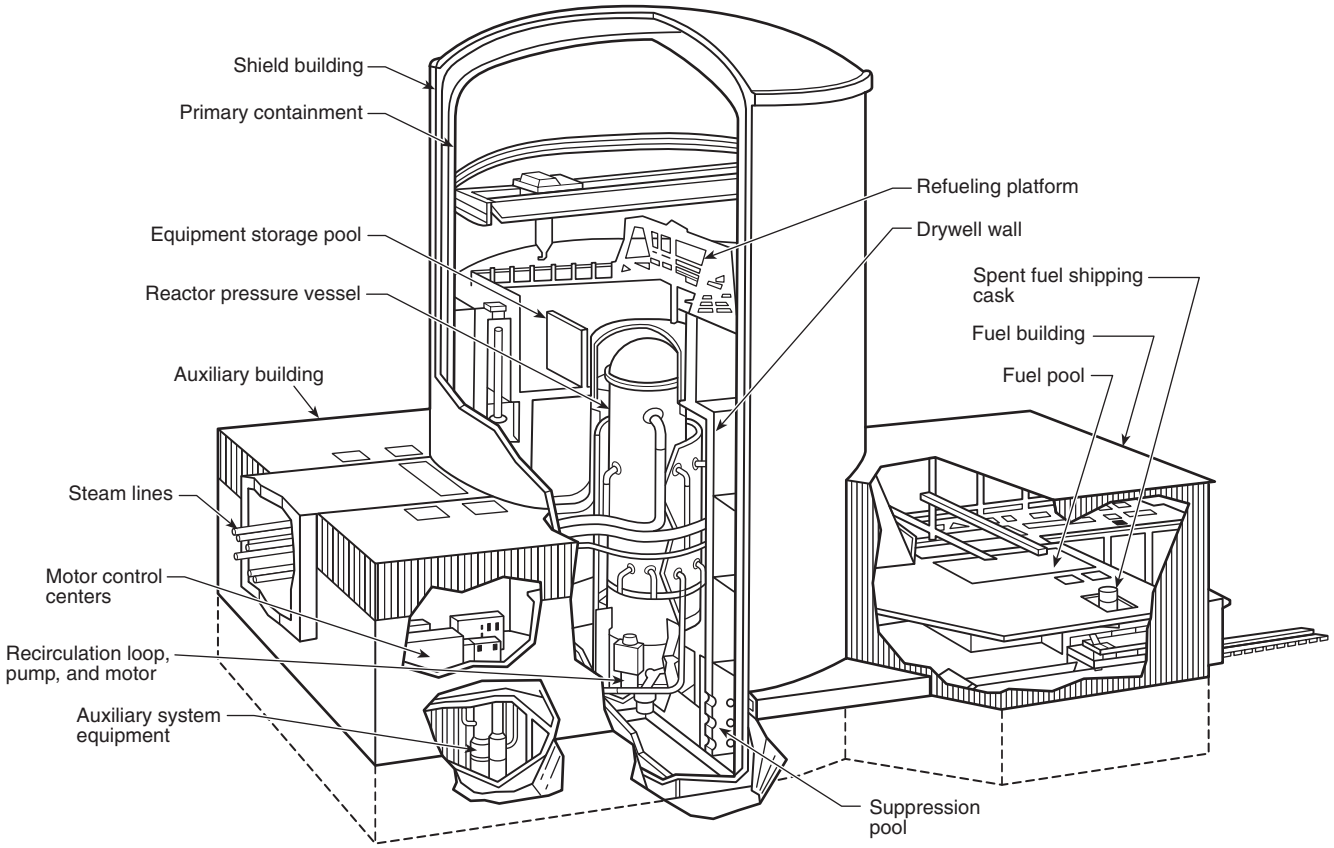

Figure 2-1 Mark III reactor building, fuel building, and auxiliary building.

4. Building materials [including polyvinyl chloride (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

(b) *Flammable Gases.* Typical examples of flammable gases found in a nuclear power plant are as follows:

1. Hydrogen for generator cooling and for any coolant conditioning of gas-cooled reactors, and hydrogen from battery charging
2. Propane or other fuel gases
3. O_2 and H_2 by radiolysis in the core and addition of H_2 for improved recombination
4. Gas for cutting and welding

(c) *Combustible Radioactive Substances.* Typical examples of radioactive substances external to the reactor are as follows:

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, radwaste materials, and so forth

3-3 Consumable Goods. While assessing the hazardous substances, ways and means of transporting the supplies of consumable goods on the site shall be considered.

3-4 Temporary Combustible Materials. Temporary but predictable and repetitive concentrations of combustible materials shall also be considered. These can include the following:

(a) Replacement of lubricating or hydraulic oils
(b) Repainting equipment or structures
(c) Replacement of combustible filter materials
(d) Scaffolding or dunnage necessary to maintain or replace equipment
(e) Spare equipment in shipping crates or boxes awaiting installation

Chapter 4 Control of Combustible Material

4-1 Limiting Combustibles. Combustibles, other than those that are an inherent part of operation, shall be restricted to protected compartments or spaces.

4-2 Reducing Fire Loads. As part of the protective measures, consideration shall be given to reducing the fire loading of contents in primary or secondary facilities by reducing the amount of combustible materials, wherever possible, as indicated in the following design features:

(a) Provision of separate piping systems for the lubricating system and control system of the turbine generators

(b) Use of an approved low-hazard synthetic hydraulic fluid in the control systems

(c) Use of approved noncombustible insulation materials on components

4-2.1 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.

4-2.2 Hydrogen. The storage and use of hydrogen shall be in accordance with NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*.

4-2.3 Flammable and combustible liquid and gas piping shall be in accordance with ASME B31.1, *Power Piping*, or ANSI B31.7, *Nuclear Power Piping*, including Addenda B-31.7a, b, and c as applicable.

Chapter 5 Construction Materials and Fire Loading in Buildings

5-1* Use of Plastics. The use of plastics such as polyurethane and polyvinyl chloride (PVC) shall be minimized and used generally at locations totally inaccessible to ignition and effects of fire exposure.

5-2 Classification of Construction Materials. Construction materials for nuclear power plants shall be classified by at least one of the following tests:

(a) NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*

(b) NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*

5-3 Combustible Construction. Certain materials of construction that do not meet the definition of noncombustible or limited combustible might have to be used in a nuclear power plant. The location of these materials in the plant, the amount exposed to ignition, and the proposed fire protection system shall be justified in writing. The approval of the plant fire protection manager and the authority having jurisdiction also shall be obtained.

5-4 Component Materials. Wall and structural components, thermal insulation materials, radiation shielding materials, and soundproofing shall be noncombustible, limited combustible, or listed by a testing laboratory for flame spread, smoke, and fuel contribution of 25 or less in their as-used configuration.

5-5 Electrical Components. Suspended ceilings, including light diffusers, and their supports shall be of noncombustible or limited-combustible construction. Electrical wiring above suspended ceilings shall be in metallic conduit or solid bottom, solid covered ferrous raceways. All other concealed spaces shall be devoid of combustibles.

5-6 Roofing Materials. Roof coverings shall be Class A as determined by tests described in NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*. Metal roof deck construction shall be Class I (Factory Mutual approved) or "fire-acceptable" (as tested by Underwriters Laboratories Inc.).

5-7 Transformers. Transformers installed inside of buildings shall be either dry type or insulated and cooled with an approved liquid, unless installed in vaults in accordance with Article 450 of NFPA 70, *National Electrical Code®*.

5-8* Cooling Towers. Cooling towers constructed of combustible or nonapproved construction shall be protected with deluge sprinkler systems in accordance with NFPA 214, *Standard on Water-Cooling Towers*. Fire hydrants shall be operational at the cooling tower site prior to beginning construction activities.

Chapter 6 General Building Arrangement

6-1 General Fire Area Requirements.

6-1.1 The nuclear power plant shall be subdivided into separate fire areas to minimize the risk of the spread of fire and the resultant consequential damage from corrosive gases, fire suppression agents, and smoke and contamination from radioactive substances. In addition, subdivisions shall provide access for manual fire suppression activities.

6-1.2* In multi-unit plants, each unit shall be separated from the other either by distance or fire barriers. The distance or fire barrier rating shall be determined from the fire hazard analysis.

6-2 Specific Fire Separation Requirements.

6-2.1 An approved fire barrier having a fire resistance rating of 3 hours, with automatic- or self-closing fire doors having a fire protection rating of 3 hours and with approved penetration protection, shall be provided to achieve the following:

(a) To separate all contiguous buildings, such as turbine, reactor containment, auxiliary fuel handling, control, radwaste, service, administration, and other areas as dictated by reactor design and fire hazard analysis

(b) To isolate turbine generator lube oil conditioning or system rooms and lube oil storage tanks from turbine buildings and adjacent areas

(c) To isolate emergency diesel generator rooms or buildings (emergency power generating areas) from each other and adjacent plant areas

(d) To separate diesel fire pumps from other pumps in the same pumphouse

(e) To separate all areas with concentrations of cables, such as cable spreading rooms, cable tunnels, cable penetration areas, cable shafts, or cable chases, included within the reactor containment, from adjacent areas

(f) To isolate auxiliary boiler rooms from adjacent areas

6-2.2 Where fire barriers are constructed to prevent vertical spread of fire, stairways, elevator shafts, and trash chutes shall be enclosed with walls or partitions having a fire resistance rating of 2 hours. Openings in such walls or partitions shall be protected with approved automatic- or self-closing fire doors having a fire protection rating of 1 $\frac{1}{2}$ hours.

6-2.3 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 or by providing a 2-hour fire barrier between transformers and exposed buildings *(see Figure 6-2.3)*. A 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.

6-3 Protection of Openings in Fire Barriers.

6-3.1 Electrical and Mechanical Penetrations. Where electrical or mechanical equipment, other than ventilation ducts, must penetrate a fire barrier, the penetration shall be sealed (firestopped) with a material or device that maintains the required fire resistance rating of the fire barrier. The penetration seal (firestop) shall be qualified in accordance with NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials,* except as modified herein:

(a) Temperatures on the unexposed surfaces of the penetration seal (firestop) shall be measured and reported to the authorities having jurisdiction. The temperatures on the unexposed side for the metallic parts of the penetration (e.g., cable trays, conductors, pipe, etc.) shall also be measured and reported to the authorities having jurisdiction. The results of the test shall be incorporated into the plant's fire hazard analysis. *(See Section 2-4.)*

(b) Immediately following the termination of the fire endurance test, a hose-stream test shall be conducted using the NFPA 251 solid-stream test or a spray-stream test conforming to the following criteria:

1. Spray nozzle that produces a long-range, narrow-angle (not exceeding 30 degrees) high-velocity spray
2. Nozzle shall discharge a minimum of 75 gpm at 75 psi at 10 ft (4.7 L/sec at 517 kPa at 3 m) from the test specimen
3. Duration of application shall be not less than $2^1/_2$ minutes for every 100 ft^2 (9 m^2) of area

(c) The penetration seal (firestop) shall be determined acceptable provided that:

1. Fire does not propagate to the unexposed side of the test assembly, nor shall there be any visible flaming on the unexposed side.
2. Temperature readings on the unexposed side shall not be high enough to ignite combustible material as evaluated in the fire hazard analysis.
3. *Penetration seal does not permit projection of water from the hose-stream test.

6-3.2 Penetrations for Ventilation Ducts. Where ventilation ducts must penetrate fire barriers, the ducts and opening protections shall comply with the provisions of Chapter 7 of this standard.

6-4 Reliability Considerations.

6-4.1* In accordance with the scope of this standard, it shall be recognized that continuing power production consideration dictates additional fire subdivision of the plant beyond that required for nuclear safety.

6-4.2 When evaluating the length of plant outage as a result of possible fire, consideration shall be given to the length of time required to satisfy the demands of all of the authorities having jurisdiction for examining causes of the fire, planning of the repairs and reconstruction, testing, and documentation of the adequacy of the restoration process.

6-4.3 Cable Construction.

6-4.3.1 Cable-insulating materials represent a major source of fire loading throughout the plant, and special consideration shall be given to their installation and protection.

6-4.3.2 As a minimum requirement, cable construction 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.

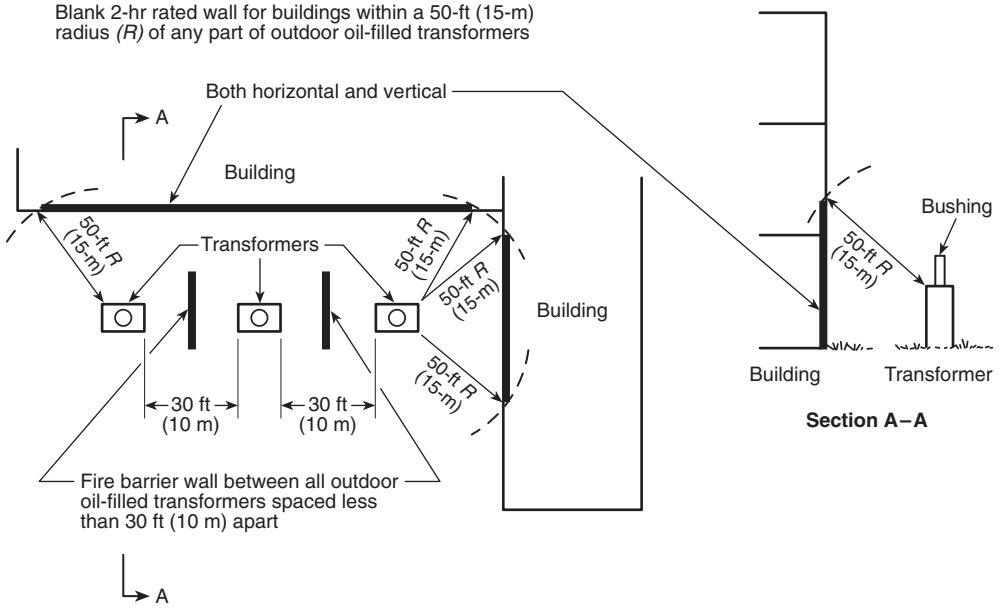

Figure 6-2.3 Outdoor oil-insulated transformer separation criteria.

Chapter 7 Heating, Ventilating, and Air Conditioning

7-1 Introduction. Ventilation of a nuclear power plant involves balanced air differentials between plant areas, comfort ventilation, and heat removal from areas where heat is generated by equipment. This need also includes fire area isolation and smoke removal equipment, as well as equipment for filtering radioactive gases. The design of ventilation systems is further complicated by the seismic, tornado, and missile criteria for building penetrations.

7-2* Basic Standards. NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems,* and NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials,* are the basic standards that shall be followed for the design, installation, and operation of the ventilation systems necessary for normal and emergency operation of the plant except for the following modifications.

7-3 General Requirements.

7-3.1 Smoke and Corrosive Gas Removal.

7-3.1.1* Automatic shutdown of ventilation systems by temperature or smoke detectors as prescribed by applicable NFPA standards in the following buildings shall be consistent with nuclear safety and safety of on-site personnel:

(a) Reactor building
(b) Auxiliary building
(c) Control building
(d) Turbine building
(e) Intake pumping station
(f) Emergency service water pumping station
(g) Condenser circulating water pumping station
(h) Electrical control and communications building
(i) Fuel building
(j) Emergency power generating building

7-3.1.2 Smoke, corrosive gases, and nonradioactive substances that might be freed by the fire shall be vented from their place of origin directly to a safe location. Radioactive materials that might be released by the fire shall be confined, removed from the exhaust ventilation airstream, or released under controlled conditions.

7-3.1.3 Ventilation systems designed to exhaust smoke or corrosive gases shall be evaluated to ensure that inadvertent operation or failures will not violate the controlled areas of the plant design.

7-3.1.4* Smoke ventilation shall be provided for fire areas based on the fire hazard analysis.

Smoke ventilation from areas that can contain radioactive substances shall not be ventilated outside the building. These smoke ventilation systems shall be connected to gas treatment systems to preclude release of radioactive substances.

7-3.1.5 The fresh-air supply intakes to all areas shall be remotely located from the exhaust air outlets and smoke vents of other fire areas to minimize the possibility of contaminating the intake air with the products of combustion.

7-3.1.6* Enclosed stairwells shall be designed to minimize smoke infiltration during a fire.

7-3.1.7* When natural-convection ventilation is used, a minimum ratio of vent area to floor area shall be 1 to 200 except in oil hazard areas where a 1 to 100 ratio shall be provided.

7-3.1.8 To prevent corrosion that might be caused by direct release of chemicals in case of a fire, the acids and alkalines used for the primary coolant treatment plant and stored in appreciable quantities on the site shall be protected so as not to increase the risk of damage in case of a fire.

7-3.1.9 The power supply and controls for mechanical ventilation systems shall be located outside the fire area served by the system or protected from fire damage.

7-3.2 Duct Systems.

7-3.2.1 Plastic ducts, including fire-retardant types, shall not be used for ventilating systems.

7-3.2.2* Ventilation ducts that pass through fire areas that they do not serve shall not degrade the fire integrity of the fire-rated enclosure.

7-3.2.3 Fire dampers shall be provided to prevent the passage of smoke, heat, or flame through ventilation ducts from one area to another.

7-3.2.4 Approved fire dampers that have a rating of 1 $^1/_2$ hours shall be installed where ventilation ducts penetrate fire barriers that have a required fire resistance rating of 2 hours or less. If ventilation ducts penetrate required 3-hour fire barriers, then approved fire dampers having a fire protection rating of 3 hours shall be installed.

Exception: Fire dampers are not required for ventilation duct penetrations where shutdown of the ventilation system is not allowed.

7-3.2.5 Fire dampers shall be equipped with thermal elements. The closure of fire dampers shall be guaranteed by mounting the damper directly into the separating wall or by protecting the duct up to the damper according to the fire resistance of the separating wall structure.

7-3.2.6* Interconnections of individual fire areas via the ventilation system shall be avoided insofar as possible. Where this is not possible, the necessary precautions shall be taken to prevent the spread of smoke and fire by such routes.

7-3.2.7 False floors or suspended ceilings shall not be employed as common pressure-equalizing chambers for redundant ventilation systems but can be used for distribution of air to the corresponding room.

7-3.3 Filters.

7-3.3.1 Air-entry filters shall have noncombustible filter media. They shall produce a minimum amount of smoke (UL Class 1) when subjected to heat. In order to decrease the fire hazard of these filters and of oil bath-type filters, only approved fire-resistive adhesives and oils with an open-cup flash point equal to or greater than 464°F (240°C) that do not produce appreciable smoke shall be used. High efficiency particulate air (HEPA) filters shall meet the requirements of UL 586, *Test Performance of High Efficiency, Particulate, Air-Filter Units.*

7-3.3.2 Fire suppression systems shall be installed to protect filters that collect combustible material, unless the elimination of such protection is justified by the fire hazard analysis.

7-3.4* Special Equipment for Emergency Personnel. Self-contained breathing apparatus (SCBA) using full-face, positive-pressure masks approved by the National Institute for Occupational Safety and Health (NIOSH) shall be provided for fire brigade and control room personnel.

Chapter 8 Fire Prevention Measures

8-1* Administrative Procedures and Controls.

8-1.1 The plant manager or delegated fire protection manager shall be responsible for ensuring that the fire hazard analysis is updated periodically.

8-1.2 The responsibilities of the plant manager or delegated fire protection manager shall be as follows:

(a) Develop, implement, and periodically update as necessary a fire brigade plan in accordance with Chapter 14.

(b) Maintain housekeeping in such a manner so as to minimize the probability of fire causing loss of life or property damage.

(c) Develop, implement, and periodically update as necessary an emergency evacuation plan for all personnel.

(d) Develop, implement, and periodically update as necessary a welding and cutting safety procedure in accordance with NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes,* and NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations. (See Chapter 15.)*

(e) Restrict smoking and other sources of ignition to properly designated and supervised safe areas of the plant.

(f) Develop, implement, and periodically update as necessary a fire prevention surveillance plan integrated with periodic recorded rounds to all accessible unattended sections of the plant.

(g) Coordinate the periodic testing of all systems and equipment affecting fire prevention and fire protection in accordance with the applicable NFPA standards or the manufacturers'/installers' instructions and procedures, or both, to include maintenance of appropriate documentation.

(h) Develop an alternate protection plan for those instances when it becomes necessary to remove any fire protection equipment or system from service.

(i) Investigate fires and coordinate all plant fire reporting (including reviewing fire reports, taking corrective action, and properly distributing the reports).

(j) Conduct periodic inspections of the plant. A prepared checklist shall be used for the inspection. The 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 a period of 2 years.

8-1.3 Plant administrative procedures shall specify appropriate requirements governing the storage, use, and handling of flammable liquids and gases.

8-1.4 Plant administrative procedures shall specify appropriate requirements governing the control of electrical appliances, that is, portable electrical heaters in critical areas.

8-1.5 The reduction and control of temporary fire loads in the plant are essential to provide defense-in-depth protection. As a minimum, plant administrative procedures shall require that the total fire loads, including temporary and permanent, shall not exceed those quantities established for extinguishment by permanently installed fire protection systems and equipment except in approved, controlled conditions. Under such conditions, the plant fire protection manager shall evaluate temporary fire loads using appropriate documented guidelines and shall be responsible for ensuring that applicable additional personnel or fire protection equipment, or both, is provided where limits are exceeded. The fire protection manager or 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. These inspections shall be documented and the records retained for a period of 2 years.

Transient fire loads, where allowed, shall be controlled and shall require the implementation of additional protective measures, such as supplemental portable fire equipment, fire-retardant impregnation, and fire watches, depending on the types and quantities of the transient combustibles and the potential fire exposure they present to the plant. Particular attention shall be given to the control of halogenated plastics. When the work is completed, the plant fire protection manager shall have the area inspected to confirm that the transient fire loads 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 a period of 2 years.

8-1.6 Plant administrative procedures shall specify that all wood routinely used in the plant shall be an approved pressure-impregnated fire-retardant type prior to being introduced into the plant.

8-1.7 Plant administrative procedures shall require an in-plant review and prior approval of all work plans in order to assess potential fire hazard situations. If such conditions are determined to exist, then special precautions shall be taken to define appropriate conditions under which the work is authorized.

8-2* Lightning Protection Measures for Buildings. The plant shall be equipped with an approved lightning protection system.

8-3 Prevention Measures for Plant Equipment.

8-3.1 The ignition of leaked or spilled oil shall be minimized by performing the following:

(a) * Keeping the oil from contact with hot parts of the steam systems (wall temperature ≥ ignition temperature), such as steam pipes and ducts, entry valve, turbine casing, reheater, and bypass valve

(b) Using suitable electrical equipment

(c) Sealing the insulation of hot plant components to prevent oil saturation

(d) Using concentric piping

8-3.2 The ignition of gas shall be minimized by providing electrical installations suitable for hazardous (classified) locations, as defined in Article 500 of NFPA 70, *National Electrical Code,* in those areas where the fire hazard analysis shows these locations to exist.

8-3.3 Ignition of flammable materials in auxiliary equipment shall be minimized as follows:

(a) Providing approved combustion safeguards on boilers and other fossil fuel-fired equipment in accordance with NFPA 8501, *Standard for Single Burner Boiler Operation,* and NFPA 8502, *Standard for the Prevention of Furnace Explosions/ Implosions in Multiple Burner Boilers*

(b) Constructing and installing equipment containing flammable or combustible liquids in accordance with NFPA 30, *Flammable and Combustible Liquids Code,* Chapter 5

(c) Equipping all oil-filled transformers with the following:

1. High oil temperature limit switches in accordance with the manufacturer's recommendations, with an audible and visual signal or an automatic device to de-energize the transformer
2. An overcurrent protection device
3. A differential relay
4. A gas detector and fault overpressure relays with a warning signal and automated shutdown for equipment over 10 MW
5. Lightning protection

(d) Equipping generators with warning signals, automated shutdown, and the following protective devices:

1. Overvoltage or undervoltage
2. Overcurrent
3. Differential relays
4. Reverse power relays
5. Proper performance of systems providing cooling and sealing gas

(e) Installing only air circuit breakers, low oil content circuit breakers, or circuit breakers filled with sulfur hexafluoride (SF_6) or similar nonflammable fluids where located indoors

8-4 Prevention Measures for Operation of the Plant. See Chapter 15.

Chapter 9 Fire-Signaling Systems

9-1 Fire-Signaling Systems.

9-1.1 Fire-signaling systems shall be provided in all areas of the plant as required by the fire hazard analysis. The requirements of this chapter constitute the minimum acceptable protective signaling system functions when used in conjunction with NFPA 72, *National Fire Alarm Code®*. All components of the fire-signaling systems shall be of an approved type.

9-1.2* The signaling system's initiating device and signaling line circuits shall provide emergency operation for fire detection, fire alarm, and waterflow alarm during a single break or a single ground fault.

9-1.3 Fire-signaling equipment used for fixed fire suppression systems shall give audible and visual alarm and system trouble annunciation in the plant control room and the plant security office. A general alarm annunciation shall be permitted to be acceptable in one of the two locations. Local alarm shall be provided in the effected fire zone and to other locations as can be required by the authority having jurisdiction.

9-1.4* Audible signaling appliances shall produce a distinctive sound that is used for no other purpose. Audible signaling devices shall be located and installed so that the alarm can be heard above ambient noise levels.

Exception: Visual signaling appliances can be used to supplement audible appliances in the protected areas. (See Section 9-4.)

9-1.5 Plant control room or plant security personnel shall be trained in the operation of all fire-signaling systems used in the plant *(see 9-1.3)*. This training shall include the ability to identify any alarm zone or fire protection system that is operating.

9-1.6 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*.

9-1.7* Manual fire alarm boxes shall be installed as required by the fire hazard analysis. If manual release devices are installed for the purpose of releasing an extinguishing agent in a fixed fire suppression system, then they shall be clearly marked for that purpose.

9-1.8 All signals shall be permanently recorded in accordance with NFPA 72, *National Fire Alarm Code*.

9-2 Fire Detectors. Automatic fire detectors shall be selected and installed in accordance with the following:

(a) NFPA 72, *National Fire Alarm Code*

(b) The design parameters required as a result of the fire hazard analysis of the plant area

(c) The additional requirements of this standard

9-3* Selection of Detectors. When the fire hazard analysis shows that fire detection is needed, Table 9-3 shall be used in selecting the type of detectors to be installed. Additional considerations prior to selection shall include the following:

(a) Response characteristics

(b) Maintenance requirements

(c) Testing requirements

(d) Adaptability to environment

(e) Accessibility

9-4 Fire-Signaling System Display and Supervision. The fire-signaling system display panel shall be located in the plant control room or the plant security office. Annunciation circuits connecting zone, main control, and remote annunciation panels shall be electrically supervised.

9-5 Maintenance, Inspection, and Acceptance Testing of Fire-Signaling Systems. Maintenance, inspection, and acceptance requirements shall be in accordance with appropriate NFPA standards for detection devices and signaling systems. The authority having jurisdiction shall be consulted on all alterations and additions to the system under its supervision.

9-6 Communications.

9-6.1 The plant public address system shall be available on a priority basis for fire announcements, directing plant fire brigades, and fire evacuation information.

9-6.2 Radio, telephone, or other two-way communication systems shall be provided.

Table 9-3 Selection of Detectors

Plant Area	Combustible Loading/ Fire Hazard (See Note 1.)	Anticipated Fire Development	Obstruction, Congestion, or Construction	Ceiling Height	Venti-lation	Radioactive Contamin-tion or Corrosion	Ambient Temperature	Acceptable Detector Choice (See Section 9-2.) *S *T *F *O (See Note 2.)			
Battery Rooms	Cable insulation plastic battery cases, wood in racks, hydrogen gas	Hydrogen explosive or Slow	Low	Low	Moderate	Potentially corrosive	Normal	X		X	X
Cable Penetration and Spreading Rooms	Cable insulation, relays, mcc	Slow	High/ moderate	Low/ moderate	Moderate	N/A	Normal	X	X		
Cable Tunnels	Cable insulation	Slow	High	Low	Variable	Variable	Variable	X	X		
Cable Shafts and Chases	Cable insulation	Slow	Variable	N/A	Variable	Variable	Variable	X	X		
Cable Tray Run Concentrations	Cable insulation	Slow	Variable	Variable	Variable	Variable	Variable	X	X		
Combustible (Charcoal) Filters	Charcoal	Slow	High	Low	Variable	Potential radiation	Normal		X		
Computer Rooms (including under floor space)	Cable insulation, Class A combustibles	Slow/fast	Moderate/ high	Low	High	N/A	Normal	X			
Control Room	Cable insula-tion, Class Acombustibles	Slow/ moderate	Moderate/ high	Low	Moderate/ high	N/A	Normal	X			
Control Room above Ceiling	Cable insulation, ducts, lighting equipment	Slow	Moderate/ high or inaccessible	Low	Variable	N/A	Normal	X			
Diesel Fire Pump Room	Oil, plastic battery cases, cable insulation	Fast	Low/ moderate	Variable	Variable	Potentially corrosive	Variable	X	X	X	
Diesel Generator Rooms	Oil, cable insulation	Fast	Low/ moderate	Variable	Modeate/ high (during opertion)	N/A	Variable	X	X	X	
Diesel Fuel Day Tank Rooms	Oil	Fast	Moderate/ high	Low	Low/mod-erate	N/A	Normal	X	X	X	
Diesel Fuel Storage Tank if Not Buried	Oil	Fast	Low	Non-outdoors Variable Indoors	Non-outdoors Variable Indoors	N/A	Normal	X	X	X	
Filter Rooms and Plenums	Charcoal	Slow/ moderate	Low/ moderate	Variable	Variable	Potential radiation	Normal	X	X		
In-Plant Flammable Liquid Storage Rooms	Low/high flash point liquids	Fast	Moderate/ high	Variable	Low/mod-erate	N/A	Normal	X	X	X	X
Fuel Oil Storage Tanks	Oil	Fast	Low	N/A Outdoors Variable Indoors	N/A Outdoors Variable Indoors	N/A	Normal		X	X	
Hydrogen Seal Oil Units	Oil, hydrogen	Fast/ extremely fast	Low/ moderate	Variable	Variable	N/A PWR potential radiation BWR	Variable		X		

Table 9-3 Selection of Detectors (Continued)

Plant Area	Combustible Loading/ Fire Hazard (See Note 1.)	Anticipated Fire Development	Obstruction, Congestion, or Construction	Ceiling Height	Ventilation	Radioactive Contamination or Corrosion	Ambient Temperature	Acceptable Detector Choice (See Section 9-2.) *S *T *F *O (See Note 2.)			
Instrument Rack Rooms	Cable, possible flammable gas	Slow/fast	Moderate/ high	Variable	Low/moderate	Potential radiation	Variable	X	X	X	
Laboratories	Chemicals, gases, liquid	Moderate/ fast	Low/ moderate	Low	Low/moderate	Potentialradiation	Normal	X	X		X
Oil Lines and Reservoirs at Steam-Driven Equipment	Oil, oil-soaked insulation	Fast/ moderate	Low	Variable	Variable	None	Variable	X	X		
Reactor/Coolant Recirculation Pumps	Oil, oil-soaked insulation	Fast/ moderate	Moderate/ high	Variable	Variable	Potential radiation	High	X	X	X	
Record Storage Rooms	Class A	Slow	Low	Low	Low	None	Normal	X	X		
Relay Rooms/ Cabinets	Cable, plastics	Slow	Moderate/ high	Low/moderate	Low/moderate	None	Variable	X	X	X	
Switchgear Rooms	Cable, electronics	Slow	Low/ moderate	Variable	Moderate/ high	None	Normal	X		X	
Transformer Outdoor (if combustible oil-filled)	Oil	Fast/ultrafast	Low	N/A	Outdoors	Weather corrosive	Normal		X	X	
Transformer Indoor (if combustible oil-filled)	Oil, cable	Fast/ultrafast	Moderate	Variable	Variable	None	Variable	X	X	X	
Turbine Building Beneath Operating Floor Where Oil Can Spread	Oil, hydrogen cable	Fast/ explosive	Variable	Variable	Variable	None–PWR potential radiation BWR	Moderate/ high		X	X	
Turbine Generator Governor Housing (if combustible fluid)	Lube oil, oil-soaked insulation	Fast/ moderate	Low	N/A	None	None–PWR potential radiation BWR	High		X	X	
Turbine Generator Bearings(seals)	Oil, oil-soaked insulation	Fast/ moderate	Low	N/A	None	None–PWR potential radiation BWR	Moderate/ high		X	X	
Turbine Oil Piping above Operating Floor	Oil	Fast	High	Low	None	None–PWR potential radiation BWR	High	X	X	X	
Generator Bearings, Seals (below operating floor)	Lube oil, hydrogen	Fast/ultrafast	High	Variable	Low	None–PWR potential radiation BWR	Moderate		X	X	
Generator Bearings, Seals (above operating floor)	Lube oil, hydrogen	Fast/ultrafast	Low	N/A	None	None–PWR potential radiation BWR	Moderate		X	X	
Turbine Generator Lube Oil Conditioning or System Room	Lube oil	Fast	Moderate	Variable	Low/ moderate	None-PWR	Moderate	X	X	X	

Table 9-3 Selection of Detectors (Continued)

Plant Area	Combustible Loading/ Fire Hazard (See Note 1.)	Anticipated Fire Development	Obstruction, Congestion, or Construction	Ceiling Height	Venti-lation	Radioactive Contamin-tion or Corrosion	Ambient Temperature	Acceptable Detector Choice (See Section 9-2.) *S *T *F *O (See Note 2.)			
Turbine Generator Lube Oil Storage Room	Lube oil, possibly hydrogen	Fast/ explosive	Moderate	Variable	Variable	None–PWR	Moderate	X	X	X	
Steam Valves (if combustible hydraulic fluid)	Hydraulic oil, oil, insulation	Fast/ moderate	Moderate/ high	Variable	Variable	None–PWR potential radiation BWR	High		X	X	
Hydrogen Manifold Areas	Hydrogen	Fast/ explosive	Low	Variable	Variable	None–PWR	Normal		X	X	X
Hydrogen Storage Outdoor	Hydrogen	Fast/ explosive	None	N/A	N/A	N/A	Normal		X	X	X
Miscellaneous Flammable Gas Storage	Miscellaneous gases	Fast/ explosive	None	Variable	Variable	N/A	Normal	X	X	X	X
Machine Shops	Various Class A and B	Moderate/ fast	None	Variable	Low	Possible radiation	Normal	X	X		
Weld Shops	Various Class A and B (Gases)	Moderate/ fast	Moderate	Variable	Low/ moderate	None	Normal		X		
Tool Cribs	Various Class A and B	Slow/ moderate	Moderate	Low	Low	None	Normal	X	X		
Warehouse Storage Rooms	Various Class A and B	Slow/ moderate	Moderate/ high	Variable	Low	None	Normal	X	X		
Truck and Railroad Unloading Areas	Various Class A and B	Moderate/ fast	Moderate	Moderate/ high	Low	Potential radiation	Normal		X		
Heating or Auxiliary Boiler Rooms	Fuel oil	Moderate/ fast	Moderate	Variable	Variable	Moderate	None	X	X	X	
Offices	Various Class A	Slow/ moderate	Low	Low	Low	None	Normal	X	X		
Cooling Towers (combustible)	Wood or plastic	Moderate/ fast	High	N/A	High	Corrosion and moisture	Normal		X		
Access Control Areas	Various Class A and B	Moderate/ fast	Moderate	Low	Variable	Potential radiation	Normal	X	X		
Locker Rooms	Various Class A	Moderate	Low	Low	Low	None	Normal	X	X		
Low Radiation Waste Storage and Process	Various Class A cable	Slow/ moderate	Low/ moderate	Variable	Low moderate	Potential radiation	Normal	X	X		
Anticontamination Clothing Storage and Cleaning	Class A	Moderate	Low/ moderate	Variable	Low/ moderate	Potential radiation	Normal	X	X		
New Fuel Storage Area	Plastic, cable	Slow	Low	Variable	Low	Potential radiation	Normal	X			
New Fuel Handling Area	Various Class A and B cable insulation	Slow/ moderate	Low	High	Low	Potential radiation	Normal	X		X	

Note 1: The combustible loading for each fire area represents combustibles normally expected in these areas, excluding transient combustibles, which shall be identified by the detailed fire hazard analysis of the respective plant area.
Note 2: Automatic sprinklers, when selected as a suppression system from Table 10-1.2, also act as thermal, spot-type detectors. This could occur if sprinklers are used in a wet pipe, dry pipe, preaction wet pilot, or preaction dry pilot configuration.
*Detector Designations: S — Smoke, T — Temperature, F — Flame, O — Other

Chapter 10 Fire Suppression Systems

10-1 General.

10-1.1 Automatic suppression systems shall be provided in all areas of the plant as required by the fire hazard analysis. Except as modified in this chapter, the following NFPA standards shall be used:

NFPA 11, *Standard for Low-Expansion Foam*

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

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*

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

NFPA 13, *Standard for the Installation of Sprinkler Systems*

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

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

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*

10-1.2 The extinguishing systems chosen shall be based on the design parameters required as a result of the fire hazard analysis. Where the fire hazard analysis shows that a fixed extinguishing system is needed, Table 10-1.2 shall be used in selecting the type of system or combination of systems to be installed.

Table 10-1.2 Suppression System Selection

	Water Systems			Gaseous Systems		Foam Systems			
Area or Hazard to Be Protected	**Automatic Sprinklers**	**Preaction Sprinklers**	**Deluge-Water Spray**	**Clean Agents**	**Carbon Dioxide**	**Mech.**	**Foam-Water Systems**	**High Expansion**	**Dry Chemical**
Auxiliary Oil or Gas Boiler Room	X	X				X (oil)	X (oil)		X
Battery Rooms	X	X		X	X				
Cable Penetration Rooms and Spreading Rooms	X (Note 1)	X (Note 1)	X (Note 1)	X (Note 2)	X (Note 2)				
Cable Tunnels, Shafts, Chases, Cable Tray Run Concentrations	X (Note 1)	X (Note 1)	X (Note 1)	X (Note 2)	X (Note 2)				X (multi purpose only)
Combustible (Charcoal) Filters			X						
Computer Rooms (including under floor space)	X	X		X	X (Note 4)				
Control Room		X		X					
Diesel Fire Pump Room	X								
Diesel Generator Rooms (Note 3^0)	X	X		X	X	X	X	X	X
Diesel Fuel Day Tank Rooms	X	X	X	X	X	X	X	X	X
Diesel Fuel Storage Tank, if Not Buried	X		X	X	X	X	X	X	X
Filter Rooms and Plenums	X	X	X						
Flammable Liquid Storage Areas	X		X	X	X	X	X	X	X
Fuel Oil Storage Tanks	X		X			X	X	X	X
Hydrogen Seal Oil Units			X						X
Instrument Rack Rooms				X	X				
Laboratories	X	X		X	X				
Oil Lines and Reservoirs at Steam Turbine Driven Equipment [if more than 50 gal (189.3 L)]	X	X	X	X (Note 5)	X (Note 5)				X
Reactor Coolant/ Recirculation Pumps	X	X	X		X	X	X		X
Record Storage Rooms	X	X		X (Note 6)	X (Note 6)				
Relay Rooms/Cabinets	X	X		X	X				
Switchgear Rooms		X		X	X				

Table 10-1.2 Suppression System Selection

Area or Hazard to Be Protected	Water Systems			Gaseous Systems		Foam Systems			Dry Chemical
	Automatic Sprinklers	Preaction Sprinklers	Deluge-Water Spray	Clean Agents	Carbon Dioxide	Mech.	Foam-Water Systems	High Expansion	
Transformer Outdoor (if combustible oil-filled)			X						
Transformer Indoor (if combustible oil-filled)	X	X	X	X	X				X
Turbine Building Beneath Operating Floor Where Oil Can Spread	X	X				X	X		X
Turbine Generator Governor Housing (if combustible fluid)		X	X	X (Note 5)	X (Note 5)				X
Turbine Generator Bearings (seals)		X	X	X (Note 5)	X (Note 5)				X
Turbine Generator Lube Oil Conditioning or System Room	X	X	X	X	X	X	X	X	X
Turbine Generator Lube Oil Storage Rooms	X	X	X	X	X	X	X	X	X
Steam Valves (if combustible hydraulic fluid)			X		X				X
Staging, Storage and Warehousing Areas	X	X						X	
Truck and Railroad Bays (other areas of combustible occupancy)	X	X							
Cooling Towers (combustible)			X						

Note 1: Systems shall be designed so that water is directed into every tray. Where closed-head sprinkler or thermal detection systems are used, means shall be provided for prompt actuation.
Note 2: Ceiling sprinklers can be required in addition.
Note 3: Release of extinguishing agent shall not be prevented if equipment is operating.
Note 4: Under floor only.
Note 5: Design concentrations shall be maintained during the entire coast down period.
Note 6: Combustible storage should be in metal cabinets.
Note 7: For normally occupied areas, ensure clean agents are suitable for application. Existing halon systems are acceptable for continued use.

10-1.3 Selection of extinguishing agents shall be based on the following:

(a) Type or class of hazard
(b) Effect of agent discharge on critical equipment such as thermal shock, continued operability, water damage, overpressurization, clean-up, and so forth
(c) Health hazards

10-1.4 A designated person(s) working in the plant shall be trained in the maintenance, inspection, operation, and emergency actuation of all fixed fire suppression systems installed in the plant, whether automatic or manual.

10-1.5* Each fire suppression system shall be equipped with approved alarm devices, annunciated locally or in the hazard area. *(See 9-1.3.)*

10-1.6* All shutoff valves controlling fire suppression systems *(see 10-2.2)* shall be supervised by one of the following methods:

(a) Electrical supervision with an audible signal annunciating in accordance with Chapter 9
(b) Locking valves open

10-2 Automatic Sprinkler and Water Spray Systems.

10-2.1* Where water is used as an extinguishing agent, systems shall be designed, installed, and maintained in accordance with the provisions of NFPA 13, *Standard for the Installation of Sprinkler Systems*, and NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*.

10-2.2* Each system shall have an independent connection to the plant yard main and be equipped with an approved indicating-type control or shutoff valve.

10-2.3* Drainage of all buildings shall be assessed to ensure acceptable runoff or retention of fire protection water and to minimize damage.

10-3 Gaseous Suppression Systems.

10-3.1 In areas where appreciable Class C hazards exist and where the use of other agents might result in equipment malfunction or damage as determined by the fire hazard analysis, gaseous extinguishing agent systems shall be installed. These systems, where required, shall be designed, installed, and maintained in accordance with the appropriate agent standard as follows:

Carbon Dioxide— NFPA 12

Halon 1301— NFPA 12A

Clean Agents— NFPA 2001

10-3.2* Where gaseous extinguishing agent systems are used, they shall be automatically actuated by an approved method of detection meeting the requirements of NFPA 72, *National Fire Alarm Code*. To ensure rapid detection, particular attention shall be given to the choice of actuation means, the airflows usually involved, and the heat release rates for the hazard under fire conditions.

10-4 Foam Systems.

10-4.1* Where fires involving flammable liquids and gases under pressure are likely, foam systems shall not be used. These systems, where required by the fire hazard analysis, shall be designed, installed, and maintained in accordance with the appropriate agent standard as follows:

Low-Expansion Foam— NFPA 11

Medium and High-Expansion Foam Systems— NFPA 11A

Deluge Foam-Water Sprinkler and Foam-Water Spray Systems— NFPA 16

10-4.2 Foam systems shall be designed to be automatically actuated by an approved method of detection meeting the requirements of NFPA 72, *National Fire Alarm Code*.

10-4.3 Foam systems shall not be used to protect hazards involving energized electrical equipment.

10-5 Dry Chemical Systems.

10-5.1* Where appreciable Class B hazards exist, dry chemical systems shall be considered as appropriate protection.

10-5.2 Where dry chemical systems are required by the fire hazard analysis, they shall be designed, installed, and maintained in accordance with the requirements of NFPA 17, *Standard for Dry Chemical Extinguishing Systems*.

10-5.3 Dry chemical systems shall be designed to be automatically actuated by an approved method of detection meeting the requirements of NFPA 72, *National Fire Alarm Code*.

Chapter 11 Yard Mains and Hydrants

11-1 Hydrants. Outdoor fire hydrants and associated equipment shall be provided on the plant site for fire suppression undertaken by the plant fire brigade in the event of a major fire.

11-2* Yard Mains. The yard mains shall be looped and shall be of sufficient size to meet the flow requirements specified in Section 12-4.

11-3 Indicator Valves. Sufficient indicator valves shall be installed to provide adequate sectional control of the fire water supply.

11-4 Hose-Stream Protection. A sufficient number of hydrants shall be installed to provide two streams for every part of the interior of each building not covered by standpipe protection and to provide hose-stream protection for every part of each building. There shall be sufficient hydrants to concentrate the required fire flow about any important structure with no hose line exceeding 500 ft (152 m) in length. Each hydrant shall have its own gate valve.

11-5* Hose Thread. American National Fire Hose connection screw thread shall be specified.

11-6 Hose Thread Adapters. Where threads of responding fire departments differ, adapters shall be provided at the hydrants.

Chapter 12 Water Supply

12-1 Water Supply. The water supply system for the permanent fire protection installation shall be determined by the fire hazard analysis.

12-2 Initial Construction. A water supply shall be provided during the initial construction period as specified in Section 16-3.

12-3 Water Loop Construction. The fire main system piping shall not serve service water system functions. The fire water loop shall meet the construction requirements of NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

12-4 Water Supply Size. The water supply for the permanent fire protection installation shall be based on the maximum automatic sprinkler or fixed water spray system demand, with a simultaneous flow of 750 gpm (2835 L/min) at grade for hose streams and the shortest portion of the fire loop main out of service.

12-4.1 The use of multiple approved fire pumps shall be based on supplying the demand required in Section 12-4 with the largest pump out of service, utilizing different power sources.

12-4.2 Fire pumps shall meet the requirements of NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps,* and shall be automatic starting.

12-5 Jockey Pump. An automatic pressure maintenance pump (jockey pump) or a head tank shall be provided to keep the fire water main pressure at approximately 10 psi (68.9 kPa) above the start pressure setting of the fire pump(s).

12-6* Water Sources. Pumps shall take suction from acceptable sources of water. If the source is from tanks, at least two tanks shall be provided, and each tank shall be sized to contain a minimum 2-hour fire water flow demand. Where tanks are used, these tanks shall be automatically filled from a source capable of providing a 2-hour supply for the fire protection requirement in 8 hours. Fire water supply tanks shall comply with NFPA 22, *Standard for Water Tanks for Private Fire Protection,* including freeze protection requirements.

12-7 Water Quality. Salt and tidal water shall not be acceptable primary natural water sources.

12-8 Supervisory Signals. The following supervisory signals, where applicable, shall be received in the control room or plant security office in accordance with Chapter 9:

(a) Pump running
(b) Power failure
(c) Failure to start
(d) Water level
(e) Pump room and tank temperatures

Chapter 13 Portable Fire Extinguishers and Hand Hose Lines

13-1 Portable and Wheeled Fire Extinguishers.

13-1.1 Portable and wheeled fire extinguishers shall be selected, installed, inspected, maintained, and tested in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*, and approved or listed by a testing laboratory.

13-1.2 A sign shall be located adjacent to each portable and wheeled fire extinguisher and shall plainly indicate the type of fire for which it is intended.

13-1.3 All persons working in an area shall be thoroughly trained in the use of all types of portable and wheeled fire extinguishers in the area and shall be familiar with the location of the extinguishers. This training shall include both the capabilities and limitations of each available type of extinguisher.

13-2 Hand Hose Lines.

13-2.1 Hand hose lines utilizing water, foam, carbon dioxide, or dry chemical shall be selected, installed, inspected, and maintained in accordance with the following NFPA standards, respectively: NFPA 14, *Standard for the Installation of Standpipe and Hose Systems;* NFPA 11, *Standard for Low-Expansion Foam;* NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems;* and NFPA 17, *Standard for Dry Chemical Extinguishing Systems.*

13-2.2 A sign shall be located adjacent to each hand hose station and shall plainly indicate the type of fire for which it is intended.

13-2.3 Designated persons working in the area shall be thoroughly trained in the inspection, location, and use of all hand hose line devices. This training shall include the capabilities and limitations for each type of hose station.

Chapter 14 Manual Fire Fighting

14-1 Availability. Manual fire-fighting forces shall be available from

(a) The plant fire brigade formed from the shift personnel
(b) * The public fire department from the nearest town

14-2* Action Plan. Detailed action plans shall be worked out by the fire protection manager for proper deployment of in-plant fire-fighting personnel. The plan shall require testing to verify its practicability and completeness by means of semiannual fire drills. Such drills shall be documented and kept on file at the plant for a minimum period of 1 year. The action plan shall consider the need for coordination between private and public fire-fighting forces during drills and emergencies.

14-3 Standard for Fire Defense Measures. All fire protection systems and devices, such as automatic fixed fire-extinguishing systems; automatic fire alarms; and various layout arrangements (e.g., fire doors, fire dampers, ventilation arrangements, smoke venting, etc.), shall be subjected to recurring and documented checks and tests. The staff shall be trained and drilled so that each person is capable of acting quickly and efficiently in the event of fire or danger of fire. A senior management representative, along with the fire protection manager, shall be responsible for ensuring that the plant fire defense is the best possible in all respects, including that all fire-fighting equipment and systems are in working order. This supervisory activity shall be done by developing a plant emergency plan.

14-4 Liaison with Public Fire Authorities. Liaison between and interfacing with the fire protection manager and the public fire authorities shall be maintained. It shall be the duty of the fire protection manager, together with the plant manager and plant security manager, in consultation with the public fire department, to make plans for fire fighting and rescue, including assistance from other organizations. These plans shall be maintained in a current mode. Fire fighters from the public fire department and from other fire departments, including other industrial fire brigades that might be expected to respond to a fire at the plant, shall be familiarized with the plant layout. The access routes to fires in the controlled area (to which access doors are locked) shall be planned in detail in advance. The public fire department shall be instructed and trained on how to react in areas where radioactive materials, radiation, or hazardous materials might be present.

14-5 Regular Training and Drills. Fire brigade members shall be given regular training and practice in fire fighting and rescue routines, including radioactivity and health physics considerations, to ensure that each member is thoroughly familiar with the steps to be taken in the event of fire. This regular training will contribute to maintaining the best possible preparedness for such contingencies. Each fire brigade member shall be capable of acting as follows:

(a) To alarm the plant fire brigade and public fire department
(b) To identify any alarm zone or fire protection system that has operated
(c) To use available rescue and extinguishing devices
(d) To actuate the fixed fire extinguishing systems, the smoke venting systems, and so forth
(e) To cooperate with and assist the public fire department in its work
(f) * To train plant personnel in room entry procedures where total flooding fire suppression systems are used

14-6 Equipment for the Plant Fire Brigade.

14-6.1* The conventional equipment for the plant fire brigade shall be selected to suit the entire plant site. To complement the conventional equipment, the following equipment shall be provided to cope with the nuclear hazard:

(a) Protective clothing
(b) * Respiratory protective equipment
(c) Radiation monitors
(d) Personal dosimeters

14-6.2 A formal program for the care and maintenance of the fire brigade equipment shall be established by the owner through the fire protection manager.

Chapter 15 Planning and Fire Protection

15-1 Responsibility. The owner or delegated fire protection manager shall be responsible for the entire fire protection of the plant site from conception and throughout the operating life of the plant. Fire protection shall be accorded the same consideration as nuclear hazards.

15-2 Design Specifications. Fire protection shall be incorporated into the design specifications for the plant.

15-3 Updates. Fire protection measures shall keep pace with the advancement of the plant construction and corresponding fire hazards.

15-4 Special-Hazard Systems. Special-hazard fire protection shall be operational prior to the introduction of the hazard, such as energizing a transformer or filling oil tanks within the plant. Fire barriers and fire doors shall be given priority for construction and installation to reduce the spread of fire.

15-5* Repairs and Revision Work. Special attention shall be paid to repairs and revision work outside of established areas. The requirement that written permission from the fire protection manager must be obtained before embarking on cutting, welding, use of other open flames in repairing fire protection systems, and similar operations shall be adopted.

Chapter 16 Fire Prevention and Fire Protection for the Construction Site

16-1* Protection. Fire at the construction site shall not threaten the safety of the operating plant.

16-2 Fire Prevention. The owner or the owner's designated fire protection manager shall be responsible for fire prevention of the entire plant site during the construction period. The duties shall be as follows:

(a) Develop, implement, and periodically update as necessary a fire procedure for the project and a fire brigade plan.

(b) Maintain housekeeping in such a manner so as to minimize the probability of fire causing loss of life or property damage.

(c) Provide periodic coordination with the public fire department and the plant fire brigade. *(See Chapter 14.)*

(d) Develop, implement, and periodically update as necessary an emergency evacuation plan for all personnel.

(e) Develop, implement, and periodically update as necessary a welding and cutting safety procedure in accordance with NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes,* and NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations.*

(f) Control the use of temporary buildings, including trailers, shacks, or shanties, within the confines of the plant.

(g) Specify the use of noncombustible scaffolds, formwork, decking, and partitions both inside and outside permanent buildings.

(h) Establish a hazardous material control plan prohibiting the storage of flammable liquids, Class II combustible liquids, gases, or other hazardous materials in permanent buildings. These materials shall be stored in a building at least 50 ft (15.2 m) from any permanent building and stored in accordance with NFPA 30, *Flammable and Combustible Liquids Code.* Flammable liquids and Class II combustible liquids shall be handled in listed containers in accordance with NFPA 30.

(i) Specify the use of approved tarpaulins.

(j) Develop, implement, and periodically update as necessary a fire prevention surveillance plan to include periodic recorded rounds to all unattended sections of the plant.

(k) Coordinate the initial and periodic testing of all systems and equipment affecting fire prevention and fire protection in accordance with the applicable NFPA standards or the manufacturers'/installers' instructions and procedures, or both, to include maintenance of appropriate documentation.

(l) Develop an alternate protection plan for those instances when it becomes necessary to remove any fire protection equipment or system from service.

(m) Specify labeled heating devices and their fuel supply systems for use inside or within 30 ft (9.1 m) of temporary and permanent buildings.

16-3 Fire Protection. The owner or the owner's designated fire protection manager shall be responsible for the provision of fire protection systems or equipment, or both, as follows:

(a) *General Alarm System.* The system(s) shall be such that personnel on the site will be alerted.

(b) *Water Supply.* Minimum construction water supply shall be available on the site and capable of furnishing at least 750 gpm (2835 L/min) plus the demand of the largest fixed water extinguishing system at a residual gauge pressure of 75 psi (517 kPa) for a minimum 2-hour duration.

(c) *Temporary Hydrant.* A temporary hydrant system with a maximum distance between any two hydrants of 250 ft (76.2 m). Hose and hydrant equipment shall be provided to ensure an overlap of protection.

(d) *Standpipe.* A standpipe system in any permanent building that has as much as 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 addressed.

(e) *Fire Extinguishers.* Fire extinguishers in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

(f) *Automatic Fire Extinguishing System.* This system in any building or area of combustible construction or occupancy (e.g., warehouses, offices, craft shops, and so forth) if there is a life safety hazard or large concentration of valuable equipment, the loss of which would cause an economic impact (e.g., delay in start-up dates) to the completed plant.

16-4 Construction Safeguards. Requirements for plants and areas under construction shall be determined by NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations,* and it is recognized that egress requirements might need to exceed those of completed facilities due to personnel, materials, and operations involved. The late stages of construction usually present the largest personnel concentration

and highest hazard to personnel from fire in the life cycle of the plant.

Chapter 17 Life Safety

17-1 *Life Safety Code®*. The *Code* shall be the standard for life safety in the design and operation of nuclear power plants.

17-2* Occupancy Classification. The operation and maintenance of a nuclear power plant involves unique operation and material in process, due to which the majority of the areas involved in the transfer of nuclear energy to electrical energy shall be considered as either a special-purpose industrial occupancy or as an occupancy in an unusual structure as defined in NFPA *101®, Life Safety Code®*. This determination shall be made in the conceptual fire hazard analysis.

Chapter 18 Referenced Publications

18-1 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.

18-1.1 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,* 1994 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 1998 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems,* 1997 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 1996 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 1996 edition.

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

NFPA 16, *Standard for the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems,* 1995 edition.

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

NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps,* 1996 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 1996 edition.

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

NFPA 30, *Flammable and Combustible Liquids Code,* 1996 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 1997 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,* 1994 edition.

NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes,* 1994 edition.

NFPA 70, *National Electrical Code®,* 1996 edition.

NFPA 72, *National Fire Alarm Code®,* 1996 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows,* 1995 edition.

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems,* 1996 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials,* 1995 edition.

NFPA *101®, Life Safety Code®,* 1997 edition.

NFPA 204M, *Guide for Smoke and Heat Venting,* 1991 edition.

NFPA 214, *Standard on Water-Cooling Towers,* 1996 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations,* 1996 edition.

NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials,* 1995 edition.

NFPA 252, *Standard Methods of Fire Tests of Door Assemblies,* 1995 edition.

NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials,* 1996 edition.

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

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems,* 1996 edition.

NFPA 8501, *Standard for Single Burner Boiler Operation,* 1997 edition.

NFPA 8502, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boilers,* 1995 edition.

18-1.2 ANSI Publication. American National Standards Institute, 1430 Broadway, New York, NY 10018.

ANSI B31.7, *Nuclear Power Piping,* 1969, (Addenda B31.7a, 1972; B31.7b, 1971; and B31.7c, 1971).

18-1.3 ASME Publications. American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ASME B31.1, *Power Piping,* 1995.

18-1.4 ASTM Publication. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 136, *Test for Behavior of Materials in a Vertical Tube Furnace at 750°C,* 1996.

18-1.5 IEEE Publication. Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

IEEE 383, *Standard for Type Test of Class IE Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations,* 1974 (Rev. 1980).

18-1.6 UL Publication. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 586, *Test Performance of High Efficiency, Particulate, Air-Filter Units,* 1996.

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 There is information contained within this standard that is applicable to reactors other than light water reactors. Principles outlined in this standard are also applicable to nuclear production reactors. Applicable guidance for design and protection of production and research reactors can be found in this standard.

A-1-4 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 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 Combustible Liquid. See NFPA 30, *Flammable and Combustible Liquids Code,* for additional information.

A-1-4 Limited Combustible. See NFPA 220, *Standard on Types of Building Construction,* for additional information.

A-1-4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-1-5.3.2 No one of these echelons can be perfect or complete by itself. Strengthening any one can compensate in some measure for weaknesses, known or unknown, in the others.

A-2-1 The nuclear power plant will generally consist of the following functional facilities, which would be expected to vary in their physical relationship to each other from plant to plant.

A-2-4 A thorough analysis of the fire potential is necessary to incorporate adequate fire protection into the facility design. Integrated design of systems is necessary to ensure the safety of the plant and the operators from the hazards of fire and to protect property and continuity of production.

Steps recommended as part of the analysis procedure are as follows.

(a) Prepare a general description of the physical characteristics of the power facilities and plant location that will outline the fire prevention and fire protection systems to be provided. Define the potential fire hazards and state the loss-limiting criteria to be used in the design of the plant.

(b) List the codes and standards that will be used for the design of the fire protection systems. Include the published standards of the National Fire Protection Association. Select the specific sections and paragraphs, not general items.

(c) Define and describe the potential fire characteristics for all individual plant areas that have combustible materials, such as maximum fire loading, hazards of flame spread, smoke generation, toxic contaminants, and fuel contributed. Consider the use and effect of noncombustible and heat-resistant materials.

(d) List the fire protection system requirements and the criteria to be used in the basic design for such items as water supply, water distribution systems, and fire pump safety.

(e) Describe the performance requirements for the detection systems, alarm systems, automatic suppression systems, manual systems, chemical systems, and gas systems for fire detection, confinement, control, and extinguishing.

(f) Develop the design considerations for suppression systems and for smoke, heat, and flame control; combustible and explosive gas control; and toxic and contaminate control. Select the operating functions of the ventilating and exhaust systems during the period of fire extinguishing and control. List the performance requirements for fire and trouble annunciator warning systems and the auditing and reporting systems.

(g) Consider the qualifications required for the personnel performing the inspection checks and the frequency of testing to maintain a reliable alarm detection system.

(h) The features of building and facility arrangements and the structural design features generally define the methods for fire prevention, fire extinguishing, fire control, and control of hazards created by fire. Fire barriers, egress, fire walls, and the isolation and containment features that should be provided for flame, heat, hot gases, smoke, and other contaminants should be carefully planned. Outline the drawings and list of equipment and devices that are needed to define the principal and auxiliary fire protection systems.

(i) Prepare a list of the dangerous and hazardous combustibles and the maximum amounts estimated to be present in the facility. Evaluate where these will be located in the facility.

(j) Review the types of fires, based on the quantities of combustible materials, the estimated severity, intensity, duration, and the hazards created. For each fire scenario reviewed, indicate the total time from the first alert of the fire hazard until safe control and extinguishment is accomplished. Describe in detail the plant systems, functions, and controls that will be provided and maintained during the fire emergency.

(k) Define the essential electric circuit integrity needed during fire. Evaluate the electrical and cable fire protection, the fire confinement control, and the fire extinguishing systems that will be required to maintain their integrity.

(l) Carefully review and describe the control and operating room areas and the protection and extinguishing systems provided thereto. Do not overlook the extra facilities provided for maintenance and operating personnel, such as kitchens, maintenance storage, and supply cabinets.

(m) Consider the fire hazards and potentials during construction of multiple units and the additional fire prevention and control provisions that will be required during the construction period where one unit is in operation. This can require additional professional fire department type of coverage.

(n) Analyze what is available in the form of "backup" or "public" fire protection to be considered for the installation. Review the "backup" fire department, equipment, manpower, special skills, and training required.

(o) List and describe the installation, testing, and inspection required during construction of the fire protection systems that demonstrate the integrity of the systems as installed. Evaluate the operational checks, inspection, and servicing required to maintain this integrity.

(p) Evaluate the program for training, updating, and maintaining competence of the station fire-fighting and operating crew. Provisions should be required to maintain and upgrade the fire-fighting equipment and apparatus during plant operation.

(q) Review the qualification requirements for the fire protection engineer or consultant who will assist in the design and selection of equipment. This person will also inspect and test the completed physical aspects of the system and develop the complete fire protection program for the operating plant.

A-5-1 Halogenated plastics, such as polyvinyl chloride (PVC), release chlorine and hydrogen chloride gas during a fire; these gases are toxic and corrosive.

A-5-8 Since cooling towers can be vital to the operation of the plant and reconstruction can be lengthy, noncombustible construction should be used.

A-6-1.2 See NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures,* for additional information.

A-6-3.1(c)3 If electrical or mechanical chases or shafts pass through a fire area without opening into that area, the penetration seals at fire barriers are not required, provided the chases or shafts are enclosed with assemblies having fire resistance ratings not less than those of the fire barriers through which they pass.

A-6-4.1 The subdivision into fire areas for redundant nuclear safety systems is covered by other documents. *(See Appendix C.)*

A fire that might be capable of damaging only one division of a redundant system, and therefore be acceptable from the standpoint of nuclear safety, might not be acceptable from a standpoint of forced plant outage. Additional fire protection systems or fire barriers can be required.

A-7-2 See NFPA 204M, *Guide for Smoke and Heat Venting,* for additional information.

A-7-3.1.1 The varying radiation dose rates found in different parts of a nuclear power plant and caused by airborne radioactive substances, radiation from plant systems, and radiation from contaminated surfaces are the reason for the subdivision of the plant premises into what are sometimes called controlled and uncontrolled areas in order to limit the exposure of the employees when working in different parts of the plant. This classification applies to normal operating conditions. The dose rates may change substantially in the event of a serious accident. The division of the premises into controlled and uncontrolled areas also affects the dividing into fire protection areas, the design of ventilation systems, and requirements concerning surface treatment of ceilings, walls, floors, etc. (*International Guidelines for Fire Protection for Nuclear Power Plants*).

The presence of gaseous or airborne radioactive substances imposes certain requirements on the pressure differentials and direction of the pressure gradient between adjoining rooms and within the ventilation systems of the plant. The radioactive substances must be kept under control by always maintaining the flow of air from the less toward the more contaminated rooms and regions. The usual way of smoke detection may therefore not always be applicable.

Depending on the type of reactor, the space, compartments, and adjoining rooms where the components of the primary reactor coolant circuit are installed may be used for emergency pressure relief in case of a rupture in the primary coolant circuit. Parts of the entire volume of the reactor building, or the containment, may be used in order to attain an acceptable equalized relief pressure. The required interconnections of the different compartments of the reactor building contradict the normal fire protection practice of subdividing large spaces into smaller isolated compartments for confinement of the damage by smoke and heat (*International Guidelines for Fire Protection for Nuclear Power Plants*).

A-7-3.1.4 Separate smoke ventilation systems are preferred; however, smoke venting can be integrated into normal ventilation systems using automatic or manually positioned dampers and motor speed control.

The lack of smoke and heat venting in areas of relatively high combustible loading can result in significant damage to structural components.

Automatic or manual actuation of smoke and heat venting will be determined by the fire hazard analysis.

A-7-3.1.6 Stairwells serve as escape routes and fire-fighting access routes. Suitable methods of ensuring a smokefree stairwell include pressurization of stairwells (*see* NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems)* and the construction of smokeproof towers (*see 5-2.3 of* NFPA *101, Life Safety Code*).

A-7-3.1.7 Where mechanical ventilation is used, 300 ft^3/min (8.5 m^3/min) is equal to 1 ft^2 (0.09 m^2) of natural convection vent area.

A-7-3.2.2 Fire dampers or fire doors compatible with the rating of the barrier can be required at the duct penetrations to the fire area. *(See 7-3.2.3.)*

A-7-3.2.6 Fire dampers in the interconnecting ventilation ducts should be provided where the ventilation system cannot be sectioned off in the normal manner. *(See 7-3.2.3.)*

A-7-3.4 Control room personnel can be furnished breathing air by a manifold system piped from a storage reservoir, if practical. Service or operating life for the self-contained units should be a minimum of $\frac{1}{2}$ hour. At least two extra air bottles should be located on site for each self-contained breathing unit. In addition, an on-site 6-hour supply of reserve air should be provided and arranged to permit quick and complete replenishment of exhausted supply air bottles as they are

returned. If compressors are used as a source of breathing air, only units approved for breathing air should be used.

A-8-1 This section provides criteria for development of administrative procedures and controls necessary for the execution of the fire prevention and protection activities and practices for the operating plant. Included herein are the minimally accepted actions required of cognizant plant management to ensure the performance of fire protection systems and personnel and compliance with the fire prevention program.

A-8-2 See NFPA 780, *Standard for the Installation of Lightning Protection Systems,* for additional information.

A-8-3.1(a) Oil pipes should be located below steam lines.

A-9-1.2 See NFPA 72, *National Fire Alarm Code,* for definitions of signaling line circuit and initiating device circuit.

A-9-1.4 See NFPA 72, *National Fire Alarm Code,* for additional information.

A-9-1.7 See NFPA 72, *National Fire Alarm Code,* for additional information.

A-9-3 Table 9-3 is intended to show the types of fire detectors that have application to hazard areas listed. In some cases, more than one type of detector should be considered by the designer for application in a specific hazard area. Within each generic type of detector, differences among specific principles of operation can suggest preference of a specific detector for specific hazards. *(See NFPA 72, National Fire Alarm Code, for additional information on detector types.)*

A-10-1.5 On wet pipe sprinkler systems, alarm check valves are preferred.

A-10-1.6 Electric valve supervision is preferred. This method of valve supervision indicates to the operator the status of fire protection control valves at any given instant. Locks or seals do not guarantee that valves are open or closed.

A-10-2.1 Hydraulically calculated systems are preferred.

A-10-2.2 Multiple sprinkler and standpipe systems can be supplied by interior headers or fire protection loops. If provided, such headers or loops are considered an extension of the yard main system and should be provided with at least two connections to the yard main. The arrangement should be supplied and valved so that no single impairment can affect sprinkler and hose protection at the same time.

A-10-2.3 Equipment vulnerable to water damage should be placed on pedestals and floor openings should be curbed or sealed.

The installation of a complete, properly engineered automatic sprinkler or water spray system in a building will generally reduce the draining and retention tank requirements, as compared to a building that relies primarily on manual fire fighting.

A-10-3.2 For carbon dioxide total flooding systems that are automatically actuated in normally occupied areas, a predischarge alarm and time delay are required to allow for personnel evacuation of the area.

For normally occupied areas, ensure clean agents are suitable for application.

Electrical equipment need not be de-energized prior to the discharge of these extinguishing agent systems, but shutdown is desirable if it can be accomplished.

A-10-4.1 Foam systems can be used in areas where appreciable Class B hazards exist, especially where flammable liquid fuel in-depth or spills are likely.

High-expansion foam systems are particularly suited for total flooding applications but should not be used in normally occupied areas.

A-10-5.1 Dry chemical systems, utilizing multipurpose dry chemical, are also effective on Class A hazards, provided that "deep-seated" fires are not likely.

Dry chemical systems can be used in conjunction with aqueous film-forming foam (AFFF) in a combined agent application, where securing action is required in addition to extinguishment.

Electrical equipment need not be de-energized prior to system discharge, but shutdown is desirable if it can be accomplished.

Due to the potential for damage to the equipment from the dry chemical and its products of decomposition where moisture and high temperatures are likely, dry chemical systems are not recommended for use in hazard areas where sensitive electrical equipment is located.

A-11-2 Twelve-inch diameter cement-lined pipe is recommended (*see* NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*). Main sizes should be designed to encompass any anticipated expansion.

The underground main should be arranged such that any one break will not put both a fixed water extinguishing system and hose lines protecting the same area out of service.

A-11-5 See NFPA 1963, *Standard for Fire Hose Connections,* for additional information.

A-12-6 The 8-hour requirement for refilling can be reduced or eliminated if the initial supply exceeds the 2-hour supply requirement on a volume/ratio basis. *(See NFPA 20, Standard for the Installation of Centrifugal Fire Pumps, for additional information.)*

A-14-1(b) Due to the relatively remote location of most nuclear plants, such departments are usually a considerable distance away.

A-14-2 Involvement of state and local agencies in semiannual drills is encouraged.

A-14-5(f) See NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, and NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, for additional information.

A-14-6.1 See NFPA 600, *Standard on Industrial Fire Brigades,* for additional information.

A-14-6-1(b) See NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service,* for additional information.

A-15-5 See NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes,* for additional information.

A-16-1 Under construction and prior to the receipt of nuclear fuel, a nuclear power plant does not differ in any fundamental respect from a conventional steam generating plant or any other industrial plant of similar size with respect to fire protection problems. Due to large numbers of on-site personnel and high-value materials, an above-average level of fire protection on the site is justified during erection of the plant. Where a nuclear power plant is constructed in the vicinity of an existing

plant, it is important that the exposure to the existing plant be taken into consideration.

A-17-2 In most fire and fire-related incidents, the primary duty of plant personnel should be to retain the integrity of systems designed for safe operation and shutdown of nuclear facilities and containment of radioactive release. Provisions should be made so that personnel can carry out this function in as safe a manner as possible with adequate means of egress and access to all areas of the plant.

Normal operation can involve relatively few personnel; however, certain activities, such as maintenance, testing, and start-up can involve a great number of occupants not necessarily familiar with plant layout and means of egress in emergency situations. Nuclear power plant design utilizes methods such as air locks and pressure differentials to segregate plant areas. These methods require full evaluation to ensure the availability of means of egress and access in emergency situations.

In evaluating the exits for a completed facility, the number of personnel and occupancy hazards during maintenance, refueling, and testing should determine the exit requirements if greater potential for fire exists under these conditions.

These classifications consider that several areas will not normally be subject to human occupancy and that radioactive material is involved.

Appendix B Referenced Publications

B-1 The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not considered part of the requirements of this standard unless also listed in Chapter 18. The edition indicated here for each reference is the current edition as of the date of the NFPA issuance of this standard.

B-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 1998 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems,* 1997 edition.

NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps,* 1996 edition.

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

NFPA 30, *Flammable and Combustible Liquids Code,* 1996 edition.

NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes,* 1994 edition.

NFPA 72, *National Fire Alarm Code®,* 1996 edition.

NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures,* 1996 edition.

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems,* 1996 edition.

NFPA *101®, Life Safety Code®,* 1997 edition.

NFPA 204M, *Guide for Smoke and Heat Venting,* 1991 edition.

NFPA 220, *Standard on Types of Building Construction,* 1995 edition.

NFPA 600, *Standard on Industrial Fire Brigades,* 1996 edition.

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

NFPA 1963, *Standard for Fire Hose Connections,* 1993 edition.

NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service,* 1997 edition.

Appendix C Codes and Standards

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

C-1 General. There are a number of publications relating to fire protection features of nuclear reactors, particularly power reactors. In terms of content, these can be grouped into two classes: those dealing with the property protection features of the plant as a whole, and those concerned with fire protection features affecting public safety or the protection of systems essential to nuclear safety of the reactor.

C-2 Regulatory Guides. Although none of these publications is mandatory, the Nuclear Regulatory Commission (NRC) must be satisfied that effective fire protection is provided before an operating license is issued. This can be done by strict adherence to the guide or by proving that alternatives will accomplish the job. However, the NRC guides are concerned with nuclear safety and protection of the public, with little direct application to the safety of employees or construction workers, or both, to property protection of the plant as a whole, or to the continuity of power production. The purpose of a regulatory guide is to "make available specific parts of the Commission regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission."

C-3 Applicable Guides. Guides relating to the fire protection of nuclear reactors are described as follows and can be obtained from the U.S. Nuclear Regulatory Commission, Washington, DC 20555.

Regulatory Guide 1.120 — Fire Protection Guidelines for Nuclear Power Plants. It contains most of the provisions described in the Standard Review Plan.

Standard Review Plan 9.5.1 — Fire Protection System. NUREG 800 is the basic NRC document delineating the NRC's review procedures for nuclear power plant applications. Section 9.5.1 covers fire protection. While intended for the regulatory staff of the NRC as guidance for review procedures, it serves as a useful planning guide to applicants. The current edition is the July 1981 revision.

Branch Technical Position APCSB 9.5-1. Guidelines for Fire Protection for Nuclear Power Plants. These guidelines are prepared by the branches having standards-making responsibilities for the subject in question, in this case, the Auxiliary Power and Control Code of Federal Regulations, 10 CFF Part 50, Appendix R — Fire Protection Program for Nuclear Power Facilities, operating prior to January 1, 1979. These are the basic, mandatory requirements of the NRC applicable to the defined facilities. The general requirement for the fire protection and prevention programs arecontained herein, as well as specific requirements for fire brigades, water supplies, safe shutdown capability protection, fire barrier seals, and other subjects.

The Federal Register, Vol. 45, No. 105, May 29, 1980, printed Appendix R, together with an analysis of the requirements and an excellent background discussion of the various NRC requirements and guides.

International Atomic Energy Agency (IAEA) Safety Guide on Fire Protection in Nuclear Power Plants. This document is currently being drafted to "provide specific guidance for the designer and the operating staff in complying with requirements for protection of systems important to nuclear safety." IAEA guides are useful references but are not mandatory in the U.S.

American Nuclear Insurers–Mutual Atomic Energy Reinsurance Pool and Nuclear Mutual Limited Standards. Each of these insurance organizations issues standards covering the fire protection of the entire nuclear power plant. Substantial compliance is required for all plants insured within the organizations. The scope of these requirements is broader than the above documents, but life safety aspects for employees and construction workers are not a specific concern.

International Guidelines for the Fire Protection of Nuclear Power Plants. This is a comprehensive document published on behalf of the national nuclear risks insurance pools and associations. This is the broadest-scope document in print covering protection features for the entire plant. Again, this is primarily property protection oriented but is basically compatible with the U.S. insurance pools requirements and is a consensus document of the insurance pools involved.

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