Chapter 3 Fundamental Fire Protection Program and Design Elements	Mapped to Reg. Guide 1.1.89 April 2001
3.1* General. This chapter contains the fundamental elements of the fire protection program and specifies the minimum design requirements for fire protection systems and features. These fire protection program elements and minimum design requirements shall not be subject to the performance-based methods permitted elsewhere in this standard. Previously approved alternatives from the fundamental protection program attributes of this chapter by the AHJ take precedence over the requirements contained herein.	
3.2 Fire Protection Plan. **3.2.1 Intent.** A site-wide fire protection plan shall be established. This plan shall document management policy and program direction and shall define the responsibilities of those individuals responsible for the plan's implementation. This section establishes the criteria for an integrated combination of components, procedures, and personnel to implement all fire protection program activities.	**1. FIRE PROTECTION PROGRAM** In accordance with 10 CFR 50.48, a fire protection program must be established at each nuclear power plant. The program should establish the fire protection policy for the protection of structures, systems, and components important to safety at each plant and the procedures, equipment, and personnel required to implement the program at the plant site.
3.2.2* Management Policy Direction and Responsibility. A policy document shall be prepared that defines management authority and responsibilities and establishes the general policy for the site fire protection program.	**1. FIRE PROTECTION PROGRAM** In accordance with 10 CFR 50.48, a fire protection program must be established at each nuclear power plant. The program should establish the fire protection policy for the protection of structures, systems, and components important to safety at each plant and the procedures, equipment, and personnel required to implement the program at the plant site. In accordance with 10 CFR 50.48, the fire protection program must: • Identify the various positions within the licensee's organization that are responsible for the program and state the authorities delegated to these positions (see Regulatory Position 1.1)
3.2.2.1* The policy document shall designate the senior management position with immediate authority and responsibility for the fire protection program.	**1.1 Organization, Staffing, and Responsibilities** The fire protection program should be under the direction of an individual who has been delegated authority commensurate with the responsibilities of the position and who has available staff personnel knowledgeable in both fire protection and nuclear safety. Responsibility for the overall fire protection program should be assigned to a person who has management

	control over all organizations involved in fire protection activities. Formulation and assurance of program implementation may be delegated to a staff composed of personnel prepared by training and experience in fire protection and personnel prepared by training and experience in nuclear plant safety to provide a comprehensive approach in directing the fire protection program for the nuclear power plant. The following positions or organizations should be designated. **a.** The upper level management position that has management responsibility for the formulation, implementation, and assessment of the effectiveness of the nuclear plant fire protection program.
3.2.2.2* The policy document shall designate a position responsible for the daily administration and coordination of the fire protection program and its implementation.	**1.1 Organization, Staffing, and Responsibilities** The following positions or organizations should be designated. **b.** The management positions directly responsible for formulating, implementing, and periodically assessing the effectiveness of the fire protection program for the licensee's nuclear power plant, including fire drills and training conducted by the fire brigade and plant personnel. The results of these assessments should be reported to the upper level management position responsible for fire protection with recommendations for improvements or corrective actions as deemed necessary. **c.** The onsite management position responsible for the overall administration of the plant operations and emergency plans that include the fire protection and prevention program and that provide a single point of control and contact for all contingencies.
3.2.2.3* The policy document shall define the fire protection interfaces with other organizations and assign responsibilities for the coordination of activities. In addition, this policy document shall identify the various plant positions having the authority for implementing the various areas of the fire protection program.	**1.1 Organization, Staffing, and Responsibilities** The following positions or organizations should be designated. **a.** The upper level management position that has management responsibility for the formulation, implementation, and assessment of the effectiveness of the nuclear plant fire protection program. **b.** The management positions directly responsible for formulating, implementing, and periodically assessing the effectiveness of the fire protection program for the licensee's nuclear power plant, including fire drills and training conducted by the fire brigade and plant personnel. The results of these assessments should be reported to the upper level management position responsible for fire protection with recommendations for improvements or corrective actions as deemed necessary. **c.** The onsite management position responsible for the overall administration of the plant operations and

	emergency plans that include the fire protection and prevention program and that provide a single point of control and contact for all contingencies. On sites with an operating reactor and with construction, modification, or decommissioning of other units under way, the superintendent of the operating plant should have the lead responsibility for site fire protection. **d.** The onsite positions that: **i.** Implement periodic inspections to minimize the amount of combustibles in plant areas important to safety; determine the effectiveness of housekeeping practices; ensure the availability and acceptable condition of all fire protection systems/equipment, emergency breathing apparatus, emergency lighting, communication equipment, fire stops, penetration seals, and fire retardant coatings; and ensure that prompt and effective corrective actions are taken to correct conditions adverse to fire protection and preclude their recurrence. **ii.** Are responsible for the firefighting training for operating plant personnel and the plant's fire brigade, design and selection of equipment, periodic inspection and testing of fire protection systems and equipment in accordance with established procedures, and evaluation of test results and determination of the acceptability of the systems under test. **iii.** Assist in the critique of all fire drills to determine how well the training objectives have been met. **iv.** Are responsible for the in-plant fire protection review of proposed work activities to identify potential transient fire hazards and specify required additional fire protection in the work activity procedure. **v.** Implement a program for indoctrination of all plant contractor personnel in appropriate administrative procedures that implement the fire protection program and the emergency procedures relative to fire protection. **vi.** Implement a program for instruction of personnel on the proper handling of accidental events such as leaks or spills of flammable materials that are related to fire protection. **vii.** Are responsible for review of hot work. **e.** The onsite position responsible for fire protection quality assurance. This position is responsible for ensuring the effective implementation of the fire protection program by planned inspections, scheduled audits, and verification that the results of these inspections and audits are promptly reported to cognizant management personnel.
3.2.2.4*	**1.8 Fire Protection Program Changes/Code**

The policy document shall identify the appropriate AHJ for the various areas of the fire protection program.	**Deviations** The "Authority Having Jurisdiction" as described in NFPA documents refers to the Director, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, or designee, consistent with the authority specified in 10 CFR 1.43.
3.2.3* Procedures. Procedures shall be established for implementation of the fire protection program. In addition to procedures that could be required by other sections of the standard, the procedures to accomplish the following shall be established: (1) * Inspection, testing, and maintenance for fire protection systems and features credited by the fire protection program (2) * Compensatory actions implemented when fire protection systems and other systems credited by the fire protection program and this standard cannot perform their intended function and limits on impairment duration (3) * Reviews of fire protection program — related performance and trends (4) Reviews of physical plant modifications and procedure changes for impact on the fire protection program (5) Long-term maintenance and configuration of the fire protection program (6) Emergency response procedures for the plant industrial fire brigade	**1. FIRE PROTECTION PROGRAM** In accordance with 10 CFR 50.48, a fire protection program must be established at each nuclear power plant. The program should establish the fire protection policy for the protection of structures, systems, and components important to safety at each plant and the procedures, equipment, and personnel required to implement the program at the plant site. **1.7.1 Design and Procurement Document Control** Measures should be established to include the guidance of this guide in design and procurement documents and that deviations therefrom are controlled such that: **c.** New designs and plant modifications, including fire protection systems, are reviewed by qualified personnel to ensure inclusion of appropriate fire protection requirements. These reviews should include items such as: Design reviews to verify adequacy of wiring isolation and cable separation criteria. • Design reviews to verify appropriate requirements for room isolation (sealing penetrations, floors, and other fire barriers). **1.7.2 Instructions, Procedures, and Drawings** Inspections, tests, administrative controls, fire drills, and training that govern the fire protection program should be prescribed by documented instructions, procedures, or drawings and should be accomplished in accordance with these documents such that: **a.** Indoctrination and training programs for fire prevention and fire fighting are implemented in accordance with documented procedures. **b.** Activities such as design, installation, inspection, test, maintenance, and modification of fire protection systems are prescribed and accomplished in accordance with documented instructions, procedures, and drawings. **c.** Instructions and procedures for design, installation, inspection, test, maintenance, modification, and administrative controls are reviewed to ensure that the proper fire protection requirements are addressed, such as control of ignition sources and combustibles, provisions for backup fire protection capability, disabling a fire protection system, and the restriction on material substitution unless specifically evaluated.

	1.7.10.1 Annual Fire Protection Audit For those licensees who have relocated audit requirements from their Technical Specifications to the QA program, "annual" fire protection audits may be changed to a "maximum interval of 24 months" by implementation of a performance-based schedule, if justified by performance reviews, provided that the maximum audit interval does not exceed the 2-year interval specified in ANSI N18.7. **2.4 Fire Protection System Maintenance and Impairments** **c.** Procedures should also contain instructions on maintaining fire protection during those periods when the fire protection system is impaired or during periods of plant maintenance, e.g., fire watches.
3.3 Prevention. A fire prevention program with the goal of preventing a fire from starting shall be established, documented, and implemented as part of the fire protection program. The two basic components of the fire prevention program shall consist of both of the following: (1) Prevention of fires and fire spread by controls on operational activities (2) Design controls that restrict the use of combustible materials The design control requirements listed in the remainder of this section shall be provided as described.	**1. FIRE PROTECTION PROGRAM** In accordance with 10 CFR 50.48, a fire protection program must be established at each nuclear power plant. The program should establish the fire protection policy for the protection of structures, systems, and components important to safety at each plant and the procedures, equipment, and personnel required to implement the program at the plant site. The fire protection program should extend the concept of defense in depth to fire protection in fire areas important to safety, with the following objectives. ● To prevent fires from starting **1.6.2 General Employee Training** Each nuclear plant employee has a responsibility in the prevention, detection, and suppression of fires. Site general employee training should introduce all personnel to the elements of the site fire protection program, including the responsibilities of the fire protection staff. Instruction should be provided on types of fires and related extinguishing agents, specific fire hazards at the site, and actions in the event of a fire suppression system actuation. General employee training should provide specific instruction to site and contractor personnel on the following: ● Administrative controls on the use of combustibles and ignition sources; and **2.1 Control of Combustibles** Fire prevention administrative controls should include procedures to control handling and use of combustibles, prohibit storage of combustibles in plant areas important to safety or establish designated storage areas with appropriate fire protection, and control use of specific combustibles (e.g., wood) in plant areas important to

	safety. **2.2 Control of Ignition Sources** Fire protection administrative controls should establish procedures to govern use of ignition sources. **2.3 Housekeeping** Administrative controls should be established to minimize fire hazards in areas containing structures, systems, and components important to safety. These controls should establish procedures to govern removal of waste, debris, scrap, oil spills, and other combustibles after completion of a work activity or at the end of the shift and to maintain housekeeping inspections. Periodic housekeeping inspections should be performed to ensure continued compliance with fire protection administrative controls.
3.3.1 Fire Prevention for Operational Activities. The fire prevention program activities shall consist of the necessary elements to address the control of ignition sources and the use of transient combustible materials during all aspects of plant operations. The fire prevention program shall focus on the human and programmatic elements necessary to prevent fires from starting or, should a fire start, to keep the fire as small as possible.	**2.1 Control of Combustibles** Fire prevention administrative controls should include procedures to control handling and use of combustibles, prohibit storage of combustibles in plant areas important to safety or establish designated storage areas with appropriate fire protection, and control use of specific combustibles (e.g., wood) in plant areas important to safety. **2.2 Control of Ignition Sources** Fire protection administrative controls should establish procedures to govern use of ignition sources. **2.3 Housekeeping** Administrative controls should be established to minimize fire hazards in areas containing structures, systems, and components important to safety. These controls should establish procedures to govern removal of waste, debris, scrap, oil spills, and other combustibles after completion of a work activity or at the end of the shift and to maintain housekeeping inspections. Periodic housekeeping inspections should be performed to ensure continued compliance with fire protection administrative controls.
3.3.1.1 General Fire Prevention Activities. The fire prevention activities shall include but not be limited to the following program elements: (1) Training on fire safety information for all employees and contractors including, as a minimum, familiarization with plant fire prevention procedures, fire reporting, and plant emergency alarms (2) * Documented plant inspections including provisions for corrective actions for conditions where unanalyzed fire hazards are identified (3) * Administrative controls addressing the	**1.6.2 General Employee Training** General employee training should provide specific instruction to site and contractor personnel on the following: ● Appropriate actions to take upon discovering a fire, including, for example, notification of the control room, attempt to extinguish fire, and actuation of local fire suppression systems. ● Actions upon hearing a fire alarm; ● Administrative controls on the use of combustibles and ignition sources; and ● The actions necessary in the event of a combustible

review of plant modifications and maintenance to ensure that both fire hazards and the impact on plant fire protection systems and features are minimized.	liquid spill or gas release/leaks.
3.3.1.2* Control of Combustible Materials. Procedures for the control of general housekeeping practices and the control of transient combustibles shall be developed and implemented. These procedures shall include but not be limited to the following program elements: (1) * Wood used within the power block shall be listed pressure-impregnated or coated with a listed fire-retardant application. *Exception: Cribbing timbers 6 in. by 6 in. (15.2 cm by 15.2 cm) or larger shall not be required to be fire-retardant treated.* (2) Plastic sheeting materials used in the power block shall be fire-retardant types that have passed NFPA 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films, large-scale tests, or equivalent. (3) Waste, debris, scrap, packing materials, or other combustibles shall be removed from an area immediately following the completion of work or at the end of the shift, whichever comes first. (4) * Combustible storage or staging areas shall be designated, and limits shall be established on the types and quantities of stored materials. (5) * Controls on use and storage of flammable and combustible liquids shall be in accordance with NFPA 30, Flammable and Combustible Liquids Code, or other applicable NFPA standards. (6) * Controls on use and storage of flammable gases shall be in accordance with applicable NFPA standards.	**2.1.1 Transient Fire Hazards** ● Use of wood inside buildings containing systems or equipment important to safety should be permitted only when suitable noncombustible substitutes are not available. All wood smaller than 152 mm x 152 mm (6 inch x 6 inch) used in plant areas important to safety during maintenance, modification, or refueling operation (such as lay-down blocks or scaffolding) should be treated with a flame retardant (see NFPA 703, "Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials," for guidance). Wood should be allowed into plant areas important to safety only when it is to be used immediately. ● The use of plastic materials should be minimized. Halogenated plastics such as polyvinyl chloride (PVC) and neoprene should be used only when substitute noncombustible materials are not available. All plastic materials, including flame and fire retardant materials, will burn with an intensity and BTU production in a range similar to that of ordinary hydrocarbons. When burning, they produce heavy smoke that obscures visibility and can plug air filters, especially charcoal and HEPA filters. The halogenated plastics also release free chlorine and hydrogen chloride when burning, which are toxic to humans and corrosive to equipment. NFPA 701, "Standard Methods of Fire Tests for Flame-Resistant Textiles and Films," provides guidance on fire testing of flame resistant plastic films (e.g., plastic sheeting, tarpaulins). **2.3 Housekeeping** Administrative controls should be established to minimize fire hazards in areas containing structures, systems, and components important to safety. These controls should establish procedures to govern removal of waste, debris, scrap, oil spills, and other combustibles after completion of a work activity or at the end of the shift and to maintain housekeeping inspections. Periodic housekeeping inspections should be performed to ensure continued compliance with fire protection administrative controls. Regulatory Guide 1.39 provides guidance on housekeeping, including the disposal of combustible materials. **2.1 Control of Combustibles** Fire prevention administrative controls should include procedures to control handling and use of combustibles,

	prohibit storage of combustibles in plant areas important to safety or establish designated storage areas with appropriate fire protection, and control use of specific combustibles (e.g., wood) in plant areas important to safety. **2.1.3 Flammable and Combustible Liquids and Gases** The handling, use, and storage of flammable and combustible liquids should, as a minimum, comply with the provisions of NFPA 30, "Flammable and Combustible Liquids Code." **7.5 Flammable Gas Storage and Distribution** Bulk gas storage (either compressed or cryogenic) should not be permitted inside structures housing equipment important to safety. Storage of flammable gas such as hydrogen should be located outdoors or in separate detached buildings so that a fire or explosion will not adversely affect any systems or equipment important to safety. NFPA 50A and 50B provide additional guidance. Care should be taken to locate high-pressure gas storage containers with the long axis parallel to building walls. This will minimize the possibility of wall penetration in the event of a container failure. Acetylene-Oxygen gas cylinder storage locations should not be in areas that contain or expose equipment important to safety or the fire protection systems that serve those equipment areas. A permit system should be required for use of Acetylene-Oxygen gas storage cylinders in areas of the plant important to safety. NFPA 55, "Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders," provides additional guidance. Risks to equipment important to safety from hydrogen supply systems can be minimized by designing hydrogen lines in plant areas important to safety to Seismic Class I requirements, sleeving the piping such that the pipe is directly vented to the outside, or through the use of restricting orifices or excess flow valves to limit the maximum flow rate from the storage facility to the areas of concern so that in case of a line break, the hydrogen concentration in the affected areas will not exceed 2%. This approach includes pre-operational testing and subsequent retesting of excess flow valves and measures to prevent buildup of unacceptable amounts of trapped hydrogen and inadvertent operation with the safety features bypassed. A somewhat less cost-effective alternative involves use of a normally isolated supply with intermittent manual makeup. Additional guidelines and criteria for the design, installation, and operation of flammable cryogenic and compressed gas systems are provided in EPRI NP-5283-SR-A.

3.3.1.3 Control of Ignition Sources. **3.3.1.3.1*** A hot work safety procedure shall be developed, implemented, and periodically updated as necessary in accordance with NFPA 51B, Standard for Fire Prevention During Welding, Cutting, and Other Hot Work, and NFPA 241, Standard for Safeguarding Construction, Alteration, and Demolition Operations.	**2.2 Control of Ignition Sources** Fire protection administrative controls should establish procedures to govern use of ignition sources. **2.2.1 Open Flame, Welding, Cutting and Grinding (Hot Work)** Work involving ignition sources such as welding and flame cutting should be done under closely controlled conditions. Persons performing and directly assisting in such work should be trained and equipped to prevent and combat fires. If this is not possible, a person qualified in fire protection should directly monitor the work and function as a fire watch. The use of ignition sources should be governed by use of a hot work permit system to control open flame, welding, cutting, brazing, or soldering operations. A separate permit should be issued for each area where work is to be done. If work continues over more than one shift, the permit should be valid for not more than 24 hours when the plant is operating or for the duration of a particular job during plant shutdown. NFPA-51B, "Standard for Fire Prevention in Use of Cutting and Welding Processes," includes guidance for safeguarding the hazards associated with welding and cutting operations.
3.3.1.3.2 Smoking and other possible sources of ignition shall be restricted to properly designated and supervised safe areas of the plant.	No similar requirement in Regulatory Guide 1.189
3.3.1.3.3 Open flames or combustion-generated smoke shall not be permitted for leak or air flow testing.	**2.2.3 Other Sources** Leak testing and similar procedures such as airflow determination should use one of the commercially available techniques. Open flames or combustion-generated smoke should not be permitted.
3.3.1.3.4* Plant administrative procedure shall control the use of portable electrical heaters in the plant. Portable fuel-fired heaters shall not be permitted in plant areas containing equipment important to nuclear safety or where there is a potential for radiological releases resulting from a fire.	**2.2.3 Other Sources** Temporary heating devices should be placed so as to avoid overturning and installed in accordance with their listing, including clearance to combustible material, equipment, or construction.
3.3.2 Structural. Walls, floors, and components required to maintain structural integrity shall be of noncombustible construction, as defined in NFPA 220, Standard on Types of Building Construction.	**4.1.1 Combustibility of Building Components and Features** According to GDC 3, noncombustible and heat resistant materials must be used wherever practical throughout the unit. Interior wall and structural components, thermal insulation materials, radiation shielding materials, and soundproofing should be noncombustible.
3.3.3 Interior Finishes.	**4.1.1.1 Interior Finish**

Interior wall or ceiling finish classification shall be in accordance with NFPA 101®, Life Safety Code®, requirements for Class A materials. Interior floor finishes shall be in accordance with NFPA 101 requirements for Class I interior floor finishes.	Interior finishes should be noncombustible. The following materials are acceptable for use as interior finish without evidence of test and listing by a recognized testing laboratory: ● Plaster, acoustic plaster, gypsum plasterboard (gypsum wallboard), either plain, wallpapered, or painted with oil- or water-base paint, ● Ceramic tile, ceramic panels, ● Glass, glass blocks, ● Brick, stone, concrete blocks, plain or painted, ● Steel and aluminum panels, plain, painted, or enameled, and ● Vinyl tile, vinyl-asbestos tile, linoleum, or asphalt tile on concrete floors. **4.1.1.2 Testing and Qualification** Interior finishes should be noncombustible (see Definitions section of this guide) or listed by an approving laboratory for: **a.** Surface flame spread rating of 25 or less, and a smoke development rating of 450 or less, when tested under ASTM E-84, "Standard Test Method for Surface Burning Characteristics of Building Materials," and **b.** Potential heat release of 8141 kJ/kg (3500 Btu/lb) or less when tested under ASTM D3286 or NFPA 259, "Standard Test Method for Potential Heat of Building Materials."[1] **c.** Floor covering critical radiant flux should be determined by testing in accordance with NFPA 253, "Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source."
3.3.4 Insulation Materials. Thermal insulation materials, radiation shielding materials, ventilation duct materials, and soundproofing materials shall be noncombustible or limited combustible.	**4.1.1 Combustibility of Building Components and Features** According to GDC 3, noncombustible and heat resistant materials must be used wherever practical throughout the unit. Interior wall and structural components, thermal insulation materials, radiation shielding materials, and soundproofing should be noncombustible.
3.3.5 Electrical. **3.3.5.1** Wiring above suspended ceiling shall be kept to a minimum. Where installed, electrical wiring shall be listed for plenum use, routed in armored cable, routed in metallic conduit, or routed in cable trays with solid metal top and bottom covers.	**4.1.1.1 Interior Finish** Suspended ceilings and their supports should be of noncombustible construction. Concealed spaces should be devoid of combustibles except as noted in Regulatory Position 6.1.2, Control Room Complex. **6.1.2 Control Room Complex** Equipment important to safety should be mounted on pedestals or the control room should have curbs and

[1] The concept of using a potential heat release limit of 8141 kJ/kg (3500 Btu/lb) is similar to the "limited combustible" concept with its like limit, as set forth in NFPA 220, "Standard on Types of Building Construction."

	drains to direct water away from such equipment. Such drains should be provided with means for closing to maintain integrity of the control room in the event of other accidents requiring control room isolation.
3.3.5.2 Only metal tray and metal conduits shall be used for electrical raceways. Thin wall metallic tubing shall not be used for power, instrumentation, or control cables. Flexible metallic conduits shall only be used in short lengths to connect components.	**4.1.3.2 Raceway/Cable Tray Construction** Only metal should be used for cable trays. Only metallic tubing should be used for conduit. Thin-wall metallic tubing should not be used. Flexible metallic tubing should only be used in short lengths to connect components to equipment. Other raceways should be made of noncombustible material. Cable raceways should be used only for cables.
3.3.5.3* Electric cable construction shall comply with a flame propagation test as acceptable to the AHJ. ~~*Exception: Existing cable in place prior to the adoption of this standard shall be permitted to remain as is.*~~	**4.1.3.1 Cable Design** Electric cable construction should pass the flame test in IEEE Standard 383, "Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations," or IEEE Standard 1202, "Standard for Flame Testing of Cables for Use in Cable Trays in Industrial and Commercial Occupancies." For cable installations in operating plants and plants under construction prior to July 1, 1976, that do not meet the IEEE Standard 383 flame test requirements, all cables should be covered with an approved flame retardant coating and properly derated, or be protected by automatic suppression.
3.3.6 Roofs. Metal roof deck construction shall be designed and installed so the roofing system will not sustain a self-propagating fire on the underside of the deck when the deck is heated by a fire inside the building. Roof coverings shall be Class A as determined by tests described in NFPA 256, Standard Methods of Fire Tests of Roof Coverings.	**4.1.1 Combustibility of Building Components and Features** Metal deck roof construction should be noncombustible and listed as "acceptable for fire" in the UL Building Materials Directory, or listed as Class I in the Factory Mutual Research Approval Guide.
3.3.7 Bulk Flammable Gas Storage. Bulk compressed or cryogenic flammable gas storage shall not be permitted inside structures housing systems, equipment, or components important to nuclear safety.	**7.5 Flammable Gas Storage and Distribution** Bulk gas storage (either compressed or cryogenic) should not be permitted inside structures housing equipment important to safety.
3.3.7.1 Storage of flammable gas shall be located outdoors, or in separate detached buildings, so that a fire or explosion will not adversely impact systems, equipment, or components important to nuclear safety. NFPA 50A, Standard for Gaseous Hydrogen Systems at Consumer Sites, shall be followed for hydrogen storage.	**2.1.4 External/Exposure Fire Hazards** When a structure, system or component important to safety is near installations, such as flammable liquid or gas storage, the risk of exposure fires (originating in such installations) to the structures, systems, and components should be evaluated and appropriate protective measures taken. NFPA 80A, "Recommended Practice for Protection of Buildings from Exterior Fire Exposures," provides guidance on such exposure protection. NFPA 30 provides guidance relative to minimum separation

Comment: NRC has disallowed this exception during the rulemaking process.

	distances from flammable and combustible liquid storage tanks. NFPA 50A, "Standard for Gaseous Hydrogen Systems at Consumer Sites," and NFPA 50B, "Standard for Liquefied Hydrogen Systems at Consumer Sites," provide separation distances for gaseous and liquefied hydrogen, respectively (see Regulatory Position 7.5). NFPA 58, "Liquefied Petroleum Gas Code," provides guidance for liquefied petroleum gas. **7.5 Flammable Gas Storage and Distribution** Storage of flammable gas such as hydrogen should be located outdoors or in separate detached buildings so that a fire or explosion will not adversely affect any systems or equipment important to safety. NFPA 50A and 50B provide additional guidance.
3.3.7.2 Outdoor high-pressure flammable gas storage containers shall be located so that the long axis is not pointed at buildings.	**7.5 Flammable Gas Storage and Distribution** Care should be taken to locate high-pressure gas storage containers with the long axis parallel to building walls. This will minimize the possibility of wall penetration in the event of a container failure.
3.3.7.3 Flammable gas storage cylinders not required for normal operation shall be isolated from the system.	**7.5 Flammable Gas Storage and Distribution** Risks to equipment important to safety from hydrogen supply systems can be minimized by designing hydrogen lines in plant areas important to safety to Seismic Class I requirements, sleeving the piping such that the pipe is directly vented to the outside, or through the use of restricting orifices or excess flow valves to limit the maximum flow rate from the storage facility to the areas of concern so that in case of a line break, the hydrogen concentration in the affected areas will not exceed 2%. This approach includes pre-operational testing and subsequent retesting of excess flow valves and measures to prevent buildup of unacceptable amounts of trapped hydrogen and inadvertent operation with the safety features bypassed. A somewhat less cost-effective alternative involves use of a normally isolated supply with intermittent manual makeup.
3.3.8 Bulk Storage of Flammable and Combustible Liquids. Bulk storage of flammable and combustible liquids shall not be permitted inside structures containing systems, equipment, or components important to nuclear safety. As a minimum, storage and use shall comply with NFPA 30, Flammable and Combustible Liquids Code.	**2.1.3 Flammable and Combustible Liquids and Gases** The handling, use, and storage of flammable and combustible liquids should, as a minimum, comply with the provisions of NFPA 30, "Flammable and Combustible Liquids Code." Miscellaneous storage and piping for flammable or combustible liquids or gases should not create a potential fire exposure hazard to systems important to safety. Systems important to safety should be isolated or separated from combustible materials. When this is not possible because of the nature of the safety system or the combustible material, special protection should be

	provided to prevent a fire from defeating the safety system function. Such protection may involve a combination of automatic fire suppression and construction capable of withstanding and containing a fire that consumes all combustibles present. Examples of such combustible materials that may not be separable from the remainder of its system are emergency diesel generator fuel oil day tanks, turbine-generator oil and hydraulic control fluid systems, and reactor coolant pump lube oil systems.
3.3.9* Transformers. Where provided, transformer oil collection basins and drain paths shall be periodically inspected to ensure that they are free of debris and capable of performing their design function.	No similar requirement in Regulatory Guide 1.189
3.3.10* Hot Pipes and Surfaces. Combustible liquids, including high flashpoint lubricating oils, shall be kept from coming in contact with hot pipes and surfaces, including insulated pipes and surfaces. Administrative controls shall require the prompt cleanup of oil on insulation.	No similar requirement in Regulatory Guide 1.189
3.3.11 Electrical Equipment Adequate clearance, free of combustible material, shall be maintained around energized electrical equipment.	No similar requirement in Regulatory Guide 1.189
3.3.12* Reactor Coolant Pumps. For facilities with non-inerted containments, reactor coolant pumps with an external lubrication system shall be provided with an oil collection system. The oil collection system shall be designed and installed such that leakage from the oil system is safely contained for off normal conditions such as accident conditions or earthquakes. All of the following shall apply. (1) The oil collection system for each reactor coolant pump shall be capable of collecting lubricating oil from all potential pressurized and non-pressurized leakage sites in each reactor coolant pump oil system. (2) Leakage shall be collected and drained to a vented closed container that can hold the inventory of the reactor coolant pump lubricating oil system. (3) A flame arrestor is required in the vent if the flash point characteristics of the oil present the hazard of a fire flashback. (4) Leakage points on a reactor coolant pump motor to be protected shall include but not be	**7.1 Reactor Coolant Pump Oil Collection** The reactor coolant pump (RCP) should be equipped with an oil collection system if the containment is not inerted during normal operation. The oil collection system should be so designed, engineered, and installed that failure will not lead to fire during normal or design basis accident conditions and that there is reasonable assurance that the system will withstand the safe shutdown earthquake. Such collection systems should be capable of collecting lube oil from all potential pressurized and unpressurized leakage sites in the RCP lube oil systems. Leakage should be collected and drained to a vented closed container that can hold the entire lube oil system inventory. A flame arrester is required in the vent if the flashpoint characteristics of the oil present the hazard of fire flashback. Leakage points to be protected should include, but are not limited to, lift pump and piping, overflow lines, lube oil cooler, oil fill and drain lines and plugs, flanged connections on oil lines, and lube oil reservoirs where such features exist on the RCPs. The drain line should be large enough to accommodate the largest potential oil leak.

limited to the lift pump and piping, overflow lines, oil cooler, oil fill and drain lines and plugs, flanged connections on oil lines, and the oil reservoirs, where such features exist on the reactor coolant pumps. (5) The collection basin drain line to the collection tank shall be large enough to accommodate the largest potential oil leak such that oil leakage does not overflow the basin.	One or more tanks need to be provided with sufficient capacity to collect the total lube oil inventory from all RCPs draining to the container. Alternatives that may be acceptable are: a. One or more tanks are provided with sufficient capacity to hold the total lube oil inventory of one RCP with margin if the tank is located such that any overflow from the tank will be drained to a safe location where the lube oil will not present an exposure fire hazard to or otherwise endanger equipment important to safety; or b. Where the RCP lube oil system is shown, by analysis, to be capable of withstanding the safe shutdown earthquake (SSE) (eliminating the consideration of simultaneous lube oil system ruptures from a seismic event), protection is provided for random leaks at mechanical joints in the lube oil system (e.g., flanges, RTD connections, sight glasses). Alternative methods of protection may be deemed acceptable for such designs. In RCP lube oil collection systems of such designs, one or more tanks need to be provided with sufficient capacity to hold the total lube oil inventory of one RCP with margin. Because protection is required only against possible leakage resulting from random leaks from the one pump at a time, any overflow from the tanks need not be considered; or c. For pumps with the lube oil contained entirely within the pump casing, an oil collection system may not be required provided it can be shown that there are no potentially significant leakage points. The guidance in Regulatory Position 7.1 is based on Appendix R to 10 CFR Part 50, CMEB 9.5-1, GL 86-10, IN 84-09, and Vollmer Memo (1983a).
3.4 Industrial Fire Brigade. **3.4.1 On-Site Fire-Fighting Capability.** All of the following requirements shall apply. (a) A fully staffed, trained, and equipped fire-fighting force shall be available at all times to control and extinguish all fires on site. This force shall have a minimum complement of five persons on duty and shall conform with the following NFPA standards as applicable: (1) NFPA 600, Standard on Industrial Fire Brigades (interior structural fire fighting) (2) NFPA 1500, Standard on Fire Department Occupational Safety and Health Program (3) NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians	**1.6.1 Fire Protection Staff Training and Qualifications** Fire protection staff should meet the following: **b.** The fire brigade members' qualifications should include satisfactory completion of a physical examination for performing strenuous activity and the fire brigade training described in Regulatory Position 1.6.4. **1.6.4 Fire Brigade Training and Qualifications** The fire brigade training program should ensure that the capability to fight credible and challenging fires is established and maintained. The program should consist of initial classroom instruction followed by periodic classroom instruction, firefighting practice, and fire drills (see Regulatory Position 3.5.1.4 for drill guidance). Numerous NFPA standards provide guidelines applicable

(b) * Industrial fire brigade members shall have no other assigned normal plant duties that would prevent immediate response to a fire or other emergency as required. (c) During every shift, the brigade leader and at least two brigade members shall have sufficient training and knowledge of nuclear safety systems to understand the effects of fire and fire suppressants on nuclear safety performance *Exception: Sufficient training and knowledge shall be permitted to be provided by an operations advisor dedicated to industrial fire brigade support criteria.* (d) * The industrial fire brigade shall be notified immediately upon verification of a fire. (e) Each industrial fire brigade member shall pass an annual physical examination to determine that he or she can perform the strenuous activity required during manual fire-fighting operations. The physical examination shall determine the ability of each member to use respiratory protection equipment.	to the training of fire brigades. The training recommendations of NFPA 600, "Industrial Fire Brigades," including the applicable NFPA publications referenced in NFPA 600, are considered appropriate criteria for training of the plant fire brigade. NFPA 1410, "Standard on Training for Initial Fire Attack," may also be used as applicable. NFPA booklets and pamphlets listed in NFPA 600 may be used as applicable for training references. In addition, courses in fire prevention and fire suppression that are recognized or sponsored by the fire protection industry should be used. **1.6.4.1 Qualifications** The brigade leader and at least two brigade members should have sufficient training in or knowledge of plant systems to understand the effects of fire and fire suppressants on safe shutdown capability. The brigade leader should be competent to assess the potential safety consequences of a fire and advise control room personnel. Such competence by the brigade leader may be evidenced by possession of an operator's license or equivalent knowledge of plant systems. Nuclear power plants staffed with a dedicated professional fire department may utilize a fire team advisor to assess the potential safety consequences of a fire and advise the control room and incident commander. The fire team advisor should possess an operator's license or equivalent knowledge of plant systems and be dedicated to supporting the fire incident commander during fire emergency events. The qualification of fire brigade members should include an annual physical examination to determine their ability to perform strenuous firefighting activities. **1.6.4.3 Fire Brigade Practice** Practice sessions should be held for each shift fire brigade on the proper method of fighting the various types of fires that could occur in a nuclear power plant. These sessions should provide brigade members with experience in actual fire extinguishment and the use of self-contained breathing apparatus under strenuous conditions encountered in fire fighting. These practice sessions should be provided at least once per year for each fire brigade member. **3.5.1.1 Fire Brigade Staffing** The fire brigade should be at least five members on each shift. The shift supervisor should not be a member of the fire brigade. **3.5.1.2 Equipment** The equipment provided for the brigade should consist of personal protective equipment such as turnout coats,

	bunker pants, boots, gloves, hard hats, emergency communications equipment, portable lights, portable ventilation equipment, and portable extinguishers. Self-contained breathing apparatus using full-face positive-pressure masks approved by NIOSH (National Institute for Occupational Safety and Health — approval formerly given by the U.S. Bureau of Mines) should be provided for fire brigade, damage control, and control room personnel. **3.5.1.3 Procedures and Pre-fire Plans** Procedures should be established to control actions by the fire brigade on notification by the control room of a fire, and to define firefighting strategies. These procedures should include: **a.** Actions to be taken by control room personnel to notify the fire brigade upon report of a fire or receipt of an alarm on the control room fire alarm panel, for example, announcing the location of the fire over the PA system, sounding fire alarms, and notifying the shift supervisor and the fire brigade leader of the type, size, and location of the fire.
3.4.2* Pre-Fire Plans. Current and detailed pre-fire plans shall be available to the industrial fire brigade for all areas in which a fire could jeopardize the ability to meet the performance criteria described in Section 1.5.	**3.5.1.3 Procedures and Pre-fire Plans** Procedures should be established to control actions by the fire brigade on notification by the control room of a fire, and to define firefighting strategies. These procedures should include: **a.** Actions to be taken by control room personnel to notify the fire brigade upon report of a fire or receipt of an alarm on the control room fire alarm panel, for example, announcing the location of the fire over the PA system, sounding fire alarms, and notifying the shift supervisor and the fire brigade leader of the type, size, and location of the fire. **b.** Actions to be taken by the fire brigade after notification by the control room of a fire, for example, assembling in a designated location, receiving directions from the fire brigade leader, and discharging specific firefighting responsibilities, including selection and transportation of firefighting equipment to the fire location, selection of protective equipment, operating instructions for use of fire suppression systems, and use of preplanned strategies for fighting fires in specific areas. **c.** Define the strategies for fighting fires in all plant areas.
3.4.2.1* The plans shall detail the fire area configuration	**3.5.1.3 Procedures and Pre-fire Plans** These strategies should designate:

and fire hazards to be encountered in the fire area, along with any nuclear safety components and fire protection systems and features that are present.	**i.** Fire hazards in each area covered by the specific pre-fire plans. **ii.** Fire suppression agents best suited for extinguishing the fires associated with the fire hazards in that area and the nearest location of these suppression agents. **iii.** Most favorable direction from which to attack a fire in each area in view of the ventilation direction, access hallways, stairs, and doors that are most likely to be free of fire, and the best station or elevation for fighting the fire. All access and egress routes that involve locked doors should be specifically identified in the procedure with the appropriate precautions and methods for access specified. **iv.** Plant systems that should be managed to reduce the damage potential during a local fire and the location of local and remote controls for such management (e.g., any hydraulic or electrical systems in the zone covered by the specific firefighting procedure that could increase the hazards in the area because of over pressurization or electrical hazards). **v.** Vital heat-sensitive system components that need to be kept cool while fighting a local fire. In particular, hazardous combustibles that need cooling should be designated. **vi.** Organization of firefighting brigades and the assignment of special duties according to job title so that all firefighting functions are covered by any complete shift personnel complement. These duties include command control of the brigade, transporting fire suppression and support equipment to the fire scenes, applying the extinguishing agent to the fire, communication with the control room, and coordination with outside fire departments. **vii.** Potential radiological and toxic hazards in fire zones. **viii.** Ventilation system operation that ensures desired plant air distribution when the ventilation flow is modified for fire containment or smoke clearing operation. **ix.** Operations requiring control room and shift engineer coordination or authorization. **x.** Instructions for plant operators and general plant personnel during fire. **xi.** Communications between the fire brigade leader, fire brigade, offsite mutual aid responders, control room, and licensee's emergency response organization. Appropriate firefighting procedures should identify the techniques and equipment for the use of water in fighting electrical cable fires in nuclear plants, particularly in areas containing a high concentration of electric cables

	with plastic insulation. Additional guidance on pre-fire planning is provided in NFPA 1620, "Recommended Practice for Pre-Incident Planning."
3.4.2.2 Pre-fire plans shall be reviewed and updated as necessary.	No similar requirement in Reg. Guide 1.189.
3.4.2.3* Pre-fire plans shall be available in the control room and made available to the plant industrial fire brigade.	No similar requirement in Reg. Guide 1.189.
3.4.2.4* Pre-fire plans shall address coordination with other plant groups during fire emergencies.	**3.5.1.3 Procedures and Pre-fire Plans** Procedures should be established to control actions by the fire brigade on notification by the control room of a fire, and to define firefighting strategies. These procedures should include: c. Define the strategies for fighting fires in all plant areas. These strategies should designate: **ix.** Operations requiring control room and shift engineer coordination or authorization. **x.** Instructions for plant operators and general plant personnel during fire.
3.4.3 Training and Drills. Industrial fire brigade members and other plant personnel who would respond to a fire in conjunction with the brigade shall be provided with training commensurate with their emergency responsibilities. (a) Plant Industrial Fire Brigade Training. All of the following requirements shall apply. (1) Plant industrial fire brigade members shall receive training consistent with the requirements contained in NFPA 600, Standard on Industrial Fire Brigades, or NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, as appropriate. (2) Industrial fire brigade members shall be given quarterly training and practice in fire fighting, including radioactivity and health physics considerations, to ensure that each member is thoroughly familiar with the steps to be taken in the event of a fire. (3) A written program shall detail the industrial fire brigade training program. (4) Written records that include but are not limited to initial industrial fire brigade classroom and hands-on training, refresher training, special training schools attended, drill attendance records, and leadership training for industrial fire brigades shall be maintained for each industrial	.**1.6.4 Fire Brigade Training and Qualifications** Numerous NFPA standards provide guidelines applicable to the training of fire brigades. The training recommendations of NFPA 600, "Industrial Fire Brigades," including the applicable NFPA publications referenced in NFPA 600, are considered appropriate criteria for training of the plant fire brigade. **1.6.4.2 Instruction** Regular planned meetings should be held at least quarterly for all brigade members to review changes in the fire protection program and other subjects as necessary. **1.6.4.4 Fire Brigade Training Records** Individual records of training provided to each fire brigade member, including drill critiques, should be maintained for at least 3 years to ensure that each member receives training in all parts of the training program. These records of training should be available for NRC review. **3.5.1.4 Performance Assessment/Drill Criteria** Fire brigade drills should be performed in the plant so that the fire brigade can practice as a team. Drills should be performed quarterly for each shift fire brigade. Each fire brigade member should participate in at least two drills per year. A sufficient number of these drills, but not less than one for each shift fire brigade per year, should be unannounced to determine the firefighting readiness of

fire brigade member. (b) Training for Non-Industrial Fire Brigade Personnel. Plant personnel who respond with the industrial fire brigade shall be trained as to their responsibilities, potential hazards to be encountered, and interfacing with the industrial fire brigade. (c) * Drills. All of the following requirements shall apply. (1) Drills shall be conducted quarterly for each shift to test the response capability of the industrial fire brigade. (2) Industrial fire brigade drills shall be developed to test and challenge industrial fire brigade response, including brigade performance as a team, proper use of equipment, effective use of pre-fire plans, and coordination with other groups. These drills shall evaluate the industrial fire brigade's abilities to react, respond, and demonstrate proper fire-fighting techniques to control and extinguish the fire and smoke conditions being simulated by the drill scenario. (3) Industrial fire brigade drills shall be conducted in various plant areas, especially in those areas identified to be essential to plant operation and to contain significant fire hazards. (4) Drill records shall be maintained detailing the drill scenario, industrial fire brigade member response, and ability of the industrial fire brigade to perform as a team. (5) A critique shall be held and documented after each drill.	the plant fire brigade, brigade leader, and fire protection systems and equipment. Persons planning and authorizing an unannounced drill should ensure that the responding shift fire brigade members are not aware that a drill is being planned until it has begun. At least one drill per year should be performed on a "back shift" for each shift fire brigade. The drills should be preplanned to establish the training objectives of the drill and should be critiqued to determine how well the training objectives have been met. Unannounced drills should be planned and critiqued by members of the management staff responsible for plant safety and fire protection. Performance deficiencies of a fire brigade or of individual fire brigade members should be remedied by scheduling additional training for the brigade or members. Unsatisfactory drill performance should be followed by a repeat drill within 30 days. The local fire department should be invited to participate at least annually. At 3-year intervals, a randomly selected unannounced drill should be critiqued by qualified individuals independent of the licensee's staff. A copy of the written report from such individuals should be available for NRC review. Drills should include the following: **a.** Assessment of fire alarm effectiveness, time required to notify and assemble the fire brigade, and selection, placement, and use of equipment and firefighting strategies. **b.** Assessment of each brigade member's knowledge of his or her role in the firefighting strategy for the area assumed to contain the fire. Assessment of the brigade members' conformance with established plant firefighting procedures and use of firefighting equipment, including self-contained emergency breathing apparatus, communication, lighting, and ventilation. **c.** The simulated use of firefighting equipment required to cope with the situation and type of fire selected for the drill. The area and type of fire chosen for the drill should differ from those used in the previous drills so that brigade members are trained in fighting fires in various plant areas. The situation selected should simulate the size and arrangement of a fire that could reasonably occur in the area selected, allowing for fire development during the time required to respond, obtain equipment, and organize for the fire, assuming loss of automatic suppression capability. **d.** Assessment of the brigade leader's direction of the

	firefighting effort as to thoroughness, accuracy, and effectiveness.
3.4.4 Fire-Fighting Equipment. Protective clothing, respiratory protective equipment, radiation monitoring equipment, personal dosimeters, and fire suppression equipment such as hoses, nozzles, fire extinguishers, and other needed equipment shall be provided for the industrial fire brigade. This equipment shall conform with the applicable NFPA standards.	**3.5.1.2 Equipment** The equipment provided for the brigade should consist of personal protective equipment such as turnout coats, bunker pants, boots, gloves, hard hats, emergency communications equipment, portable lights, portable ventilation equipment, and portable extinguishers. Self-contained breathing apparatus using full-face positive-pressure masks approved by NIOSH (National Institute for Occupational Safety and Health — approval formerly given by the U.S. Bureau of Mines) should be provided for fire brigade, damage control, and control room personnel. At least 10 masks should be available for fire brigade personnel. Control room personnel may be furnished breathing air by a manifold system piped from a storage reservoir if practical. Service or rated operating life should be at least one-half hour for the self-contained units. Additional guidance is provided in NFPA 1404, “Standard for a Fire Department Self-Contained Breathing Apparatus Program.” At least a 1-hour supply of breathing air in extra bottles should be located on the plant site for each unit of self-contained breathing apparatus. In addition, an onsite 6-hour supply of reserve air should be provided for the fire brigade personnel and arranged to permit quick and complete replenishment of exhausted air supply bottles as they are returned. If compressors are used as a source of breathing air, only units approved for breathing air should be used and the compressors should be operable assuming a loss of offsite power. Special care should be taken to locate the compressor in areas free of dust and contaminants. During refueling and maintenance periods, adequate self-contained breathing apparatus should be provided near the containment entrances for firefighting and damage control personnel. These units should be independent of any breathing apparatus or air supply systems provided for general plant activities and should be clearly marked as emergency equipment.
3.4.5 Off-Site Fire Department Interface. **3.4.5.1 Mutual Aid Agreement.** Off-site fire authorities shall be offered a plan for their interface during fires and related emergencies on site.	**3.5.2 Offsite Manual Fire-Fighting Resources** Arrangements with offsite fire services may be necessary to augment onsite firefighting capabilities, consistent with the fire hazards analysis and pre-fire planning documents. **3.5.2.3 Agreement/Plant Exercise** Written mutual aid agreements should be established between the utility and the offsite fire departments that are assumed in the fire hazards analysis and pre-fire

	plans to support response to a plant fire. These agreements should delineate fire protection authorities, responsibilities, and accountabilities with regard to responding to plant fire or emergency events, including the fire event command structure between the plant fire brigade and offsite responders.
3.4.5.2* Site-Specific Training. Fire fighters from the off-site fire authorities who are expected to respond to a fire at the plant shall be offered site-specific training and shall be invited to participate in a drill at least annually.	**3.5.2.2 Training** Local offsite fire department personnel providing back up manual firefighting resources should be trained in: **a.** Operational precautions when fighting fires on nuclear power plant sites and the need for radiological protection of personnel and the special hazards associated with a nuclear power plant site. **b.** The procedures for notification and expected roles of the offsite responders. **c.** Site access procedures and the identity (by position and title) of the individual in the onsite organization who will control the responders' support activities. Offsite response support personnel should be provided with appropriate identification cards where required. **d.** Fire protection authorities, responsibilities, and accountabilities with regard to responding to a plant fire, including the fire event command structure between the plant fire brigade and offsite responders. **e.** Plant layout, plant fire protection systems and equipment, plant fire hazards, and pre-fire response plans and procedures. **3.5.2.3 Agreement/Plant Exercise** The plant fire brigade drill schedule should provide for periodic local fire department participation (at least annually). These drills should effectively exercise the fire event command structure between the plant fire brigade and offsite responders. Offsite fire department response should be tested periodically in conjunction with the required exercises of the radiological emergency response plan required by 10 CFR 50.47.
3.4.5.3* Security and Radiation Protection. Plant security and radiation protection plans shall address off-site fire authority response.	**3.5.2 Offsite Manual Fire-Fighting Resources** Onsite fire brigades typically fulfill the role of first responder, but may not have sufficient personnel, equipment, and capability to handle all possible fire events. Arrangements with offsite fire services may be necessary to augment onsite firefighting capabilities, consistent with the fire hazards analysis and pre-fire planning documents. **3.5.2.3 Agreement/Plant Exercise** Offsite fire department response should be tested periodically in conjunction with the required exercises of the radiological emergency response plan required by 10 CFR 50.47.

3.4.6* Communications. An effective emergency communications capability shall be provided for the industrial fire brigade.	**3.5.1.2 Equipment** The equipment provided for the brigade should consist of personal protective equipment such as turnout coats, bunker pants, boots, gloves, hard hats, emergency communications equipment, portable lights, portable ventilation equipment, and portable extinguishers. **4.1.7 Communications** The communication system design should provide effective communication between plant personnel in all vital areas during fire conditions under maximum potential noise levels. Two-way voice communications are vital to safe shutdown and emergency response in the event of fire. Suitable communication devices should be provided as follows. **a.** Fixed emergency communications independent of the normal plant communication system should be installed at pre-selected stations. **b.** A portable radio communications system should be provided for use by the fire brigade and other operations personnel required to achieve safe plant shutdown. This system should not interfere with the communications capabilities of the plant security force. Fixed repeaters installed to permit use of portable radio communication units should be protected from exposure fire damage. Pre-operational and periodic testing should demonstrate that the frequencies used for portable radio communication will not affect the actuation of protective relays.
3.5 Water Supply. **3.5.1** A fire protection water supply of adequate reliability, quantity, and duration shall be provided by one of the two following methods. (a) Provide a fire protection water supply of not less than two separate 300,000-gal (1,135,500-L) supplies. (b) Calculate the fire flow rate for 2 hours. This fire flow rate shall be based on 500 gpm (1892.5 L/min) for manual hose streams plus the largest design demand of any sprinkler or fixed water spray system(s) in the power block as determined in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, or NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection. The fire water supply shall be capable of delivering this design demand with the hydraulically least demanding portion of fire main loop out of service.	**3.2.1 Fire Protection Water Supply** **(b)** The fire water supply should be calculated on the basis of the largest expected flow rate for a period of 2 hours, but not less than 1,136,000 L (300,000 gallons). This flow rate should be based (conservatively) on 1900 L/m (500 gpm) for manual hose streams plus the largest design demand of any sprinkler or deluge system as determined in accordance with NFPA 13, "Standard for the Installation of Sprinkler Systems," or NFPA 15, "Standard for Water Spray Fixed Systems for Fire Protection." The fire water supply should be capable of delivering this design demand over the longest piping route of the water supply system.

3.5.2* The tanks shall be interconnected such that fire pumps can take suction from either or both. A failure in one tank or its piping shall not allow both tanks to drain. The tanks shall be designed in accordance with NFPA 22, Standard for Water Tanks for Private Fire Protection. *Exception No. 1: Water storage tanks shall not be required when fire pumps are able to take suction from a large body of water (such as a lake), provided each fire pump has its own suction and both suctions and pumps are adequately separated.* *Exception No. 2: Cooling tower basins shall be an acceptable water source for fire pumps when the volume is sufficient for both purposes and water quality is consistent with the demands of the fire service.*	**3.2.1 Fire Protection Water Supply** NFPA 22, "Standard for Water Tanks for Private Fire Protection," and NFPA 24, "Standard for the Installation of Private Fire Service Mains and Their Appurtenances," provide guidance for fire protection water supplies. The fire protection water supply system should meet the following criteria. **(a)** Two separate, reliable freshwater supplies should be provided. Saltwater or brackish water should not be used unless all freshwater supplies have been exhausted. **(c)** If tanks are used for water supply, two 100% system capacity tanks [minimum of 1,136,000 L (300,000 gallons) each] should be installed. They should be so interconnected that pumps can take suction from either or both. However, a failure in one tank or its piping should not cause both tanks to drain. Water supply capacity should be capable of refilling either tank in 8 hours or less. **(e)** Freshwater lakes or ponds of sufficient size may qualify as the sole source of water for fire protection but require separate redundant suctions in one or more intake structures. These supplies should be separated so that a failure of one supply will not result in a failure of the other supply. **(f)** When a common water supply is permitted for fire protection and the ultimate heat sink, the following conditions should also be satisfied: **(i)** The additional fire protection water requirements are designed into the total storage capacity, and **(ii)** Failure of the fire protection system should not degrade the function of the ultimate heat sink. **(i)** Fire water supplies should be filtered and treated as necessary to prevent or control biofouling or microbiologically induced corrosion of fire water systems. If the supply is raw service water, fire water piping runs should be periodically flushed and flow tested. **6.2.6 Cooling Towers** Cooling towers should be of noncombustible construction or so located and protected that a fire will not adversely affect any systems or equipment important to safety. Cooling towers should be of noncombustible construction when the basins are used for the ultimate heat sink or for the fire protection water supply.
3.5.3* Fire pumps, designed and installed in accordance with NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection, shall be	**3.2.2 Fire Pumps** Fire pump installations should conform to NFPA 20, "Standard for the Installation of Centrifugal Fire Pumps," and should meet the following criteria.

provided to ensure that 100 percent of the required flow rate and pressure are available assuming failure of the largest pump or pump power source.	**(a)** If fire pumps are required to meet system pressure or flow requirements, a sufficient number of pumps is provided to ensure that 100% capacity will be available assuming failure of the largest pump or loss of offsite power (e.g., three 50% pumps or two 100% pumps). This can be accomplished, for example, by providing either electric motor-driven fire pumps and diesel-driven fire pumps or two or more seismic Category I Class 1E electric motor-driven fire pumps connected to redundant Class 1E emergency power buses (see Regulatory Guides 1.6, 1.32, and 1.75.)
3.5.4 At least one diesel engine-driven fire pump or two more seismic Category I Class IE electric motor-driven fire pumps connected to redundant Class IE emergency power buses capable of providing 100 percent of the required flow rate and pressure shall be provided.	**3.2.2 Fire Pumps** Fire pump installations should conform to NFPA 20, "Standard for the Installation of Centrifugal Fire Pumps," and should meet the following criteria. **(a)** If fire pumps are required to meet system pressure or flow requirements, a sufficient number of pumps is provided to ensure that 100% capacity will be available assuming failure of the largest pump or loss of offsite power (e.g., three 50% pumps or two 100% pumps). This can be accomplished, for example, by providing either electric motor-driven fire pumps and diesel-driven fire pumps or two or more seismic Category I Class 1E electric motor-driven fire pumps connected to redundant Class 1E emergency power buses (see Regulatory Guides 1.6, 1.32, and 1.75.)
3.5.5 Each pump and its driver and controls shall be separated from the remaining fire pumps and from the rest of the plant by rated fire barriers.	**3.2.2 Fire Pumps** **(b)** … Each pump and its driver and controls are located in a room separated from the remaining fire pumps by a fire wall with a minimum rating of 3 hours.
3.5.6 Fire pumps shall be provided with automatic start and manual stop only.	No similar requirement in Reg. Guide 1.189. May be tacitly covered by the following statement. **3.2.2 Fire Pumps** Fire pump installations should conform to NFPA 20, "Standard for the Installation of Centrifugal Fire Pumps."
3.5.7 Individual fire pump connections to the yard fire main loop shall be provided and separated with sectionalizing valves between connections.	**3.2.2 Fire Pumps** **(b)** Individual fire pump connections to the yard fire main loop are separated with sectionalizing valves between connections.
3.5.8 A method of automatic pressure maintenance of the fire protection water system shall be provided independent of the fire pumps.	No similar requirement in Reg. Guide 1.189. May be tacitly covered by the following statement. **3.2.2 Fire Pumps** Fire pump installations should conform to NFPA 20, "Standard for the Installation of Centrifugal Fire Pumps."
3.5.9	**3.2.2 Fire Pumps**

Means shall be provided to immediately notify the control room, or other suitable constantly attended location, of operation of fire pumps.	**(d)** Alarms or annunciators to indicate pump running, driver availability, failure to start, and low fire-main pressure are provided in the control room.
3.5.10 An underground yard fire main loop, designed and installed in accordance with NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances, shall be installed to furnish anticipated water requirements.	**3.2.3** **Fire Mains** An underground yard fire main loop should be installed to furnish anticipated water requirements. NFPA 24 provides appropriate guidance for such installation.
3.5.11 Means shall be provided to isolate portions of the yard fire main loop for maintenance or repair without simultaneously shutting off the supply to both fixed fire suppression systems and fire hose stations provided for manual backup. Sprinkler systems and manual hose station standpipes shall be connected to the plant fire protection water main so that a single active failure or a crack to the water supply piping to these systems can be isolated so as not to impair both the primary and backup fire suppression systems.	**3.2.3** **Fire Mains** **(g)** Sectional control valves are provided to isolate portions of the fire main for maintenance or repair without shutting off the supply to primary and backup fire suppression systems serving areas that contain or expose equipment important to safety. **(i)** Sprinkler systems and manual hose station standpipes have connections to the yard main system so that a single active failure or a line break cannot impair both the primary and backup fire suppression systems. Alternatively, headers fed from each end are permitted inside buildings to supply both sprinkler and standpipe systems, provided steel piping and fittings meeting the requirements of ASME/ANSI B31.1 are used for the headers up to and including the first valve supplying the sprinkler systems where such headers are part of the seismically analyzed hose standpipe system. When provided, such headers are considered an extension of the yard main system. Each sprinkler and standpipe system should be equipped with OS&Y (outside screw and yoke) gate valve or other approved shutoff valve and water flow alarm.
3.5.12 Threads compatible with those used by local fire departments shall be provided on all hydrants, hose couplings, and standpipe risers. *Exception: Fire departments shall be permitted to be provided with adapters that allow interconnection between plant equipment and the fire department equipment if adequate training and procedures are provided.*	**3.4.2** **Hydrants and Hose Houses** Threads compatible with those used by local fire departments should be provided on all hydrants, hose couplings, and standpipe risers. Alternatively, a sufficient number of hose thread adapters may be provided. **3.5.2** **Offsite Manual Fire-Fighting Resources** **3.5.2.1** **Capabilities.** The local offsite fire departments providing back up manual firefighting resources should have the following capabilities: **(b)** Hose threads or adapters to connect with onsite hydrants, hose couplings, and standpipe risers. (Regulatory Position 3.4.2 states that onsite fire suppression water systems should have threads compatible with those used by local fire departments or a

	sufficient number of thread adapters available.)
3.5.13 Headers fed from each end shall be permitted inside buildings to supply both sprinkler and standpipe systems, provided steel piping and fittings meeting the requirements of ANSI B31.1, Code for Power Piping, are used for the headers (up to and including the first valve) supplying the sprinkler systems where such headers are part of the seismically analyzed hose standpipe system. Where provided, such headers shall be considered an extension of the yard main system. Each sprinkler and standpipe system shall be equipped with an outside screw and yoke (OS&Y) gate valve or other approved shutoff valve.	**3.2.3 Fire Mains** **(i)** Sprinkler systems and manual hose station standpipes have connections to the yard main system so that a single active failure or a line break cannot impair both the primary and backup fire suppression systems. Alternatively, headers fed from each end are permitted inside buildings to supply both sprinkler and standpipe systems, provided steel piping and fittings meeting the requirements of ASME/ANSI B31.1 are used for the headers up to and including the first valve supplying the sprinkler systems where such headers are part of the seismically analyzed hose standpipe system. When provided, such headers are considered an extension of the yard main system. Each sprinkler and standpipe system should be equipped with OS&Y (outside screw and yoke) gate valve or other approved shutoff valve and water flow alarm.
3.5.14* All fire protection water supply and fire suppression system control valves shall be under a periodic inspection program and shall be supervised by one of the following methods. (a) Electrical supervision with audible and visual signals in the main control room or other suitable constantly attended location. (b) Locking valves in their normal position. Keys shall be made available only to authorized personnel. (c) Sealing valves in their normal positions. This option shall be utilized only where valves are located within fenced areas or under the direct control of the owner/operator.	**3.2.3 Fire Mains** **(d)** Control and sectionalizing valves in fire mains and water-based fire suppression systems are electrically supervised or administratively controlled (e.g., locked valves with key control, tamper-proof seals). The electrical supervision signal indicates in the control room. All valves in the fire protection system are periodically checked to verify position (see NFPA 25, "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems," for guidance).
3.5.15 Hydrants shall be installed approximately every 250 ft (76 m) apart on the yard main system. A hose house equipped with hose and combination nozzle and other auxiliary equipment specified in NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances, shall be provided at intervals of not more than 1000 ft (305 m) along the yard main system. *Exception: Mobile means of providing hose and associated equipment, such as hose carts or trucks, shall be permitted in lieu of hose houses. Where provided, such mobile equipment shall be equivalent to the equipment supplied by three hose houses.*	**3.4.2 Hydrants and Hose Houses** Outside manual hose installation should be sufficient to provide an effective hose stream to any onsite location where fixed or transient combustibles could jeopardize equipment important to safety. Hydrants should be installed approximately every 76 m (250 ft) on the yard main system. A hose house equipped with hose and combination nozzle and other auxiliary equipment recommended in NFPA 24 should be provided as needed, but at least every 305 m (1,000 ft). Alternatively, mobile means of providing hose and associated equipment, such as hose carts or trucks, may be used. When provided, such mobile equipment should be equivalent to the equipment supplied by three hose houses.

3.5.16* The fire protection water supply system shall be dedicated for fire protection use only. *Exception No. 1: Fire protection water supply systems shall be permitted to be used to provide backup to nuclear safety systems, provided the fire protection water supply systems are designed and maintained to deliver the combined fire and nuclear safety flow demands for the duration specified by the applicable analysis.* *Exception No. 2: Fire protection water storage can be provided by plant systems serving other functions, provided the storage has a dedicated capacity capable of providing the maximum fire protection demand for the specified duration as determined in this section.*	**3.2.1 Fire Protection Water Supply** The fire protection water supply system should meet the following criteria. **(d)** Common water supply tanks are acceptable for fire and sanitary or service water storage. When this is done, however, minimum fire water storage requirements should be dedicated by passive means, for example, use of a vertical standpipe for other water services. Administrative controls, including locks for tank outlet valves, are unacceptable as the only means to ensure minimum water volume. **(f)** When a common water supply is permitted for fire protection and the ultimate heat sink, the following conditions should also be satisfied: **(i)** The additional fire protection water requirements are designed into the total storage capacity, and **(ii)** Failure of the fire protection system should not degrade the function of the ultimate heat sink. **(g)** Other water systems that may be used as one of the two fire water supplies should be permanently connected to the fire main system and should be capable of automatic alignment to the fire main system. Pumps, controls, and power supplies in these systems should satisfy the requirements for the main fire pumps. The use of other water systems for fire protection should not be incompatible with their functions required for safe plant shutdown. Failure of the other system should not degrade the fire main system.
3.6 Standpipe and Hose Stations. **3.6.1** For all power block buildings, Class III standpipe and hose systems shall be installed in accordance with NFPA 14, Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems.	**3.4.1 Standpipes and Hose Stations** Interior manual hose installation should be able to reach any location that contains, or could present a fire exposure hazard to, equipment important to safety with at least one effective hose stream. To accomplish this, standpipes with hose connections equipped with a maximum of 30.5 m (100 feet) of 38 mm (1-1/2-inches) woven-jacket, lined fire hose and suitable nozzles should be provided in all buildings on all floors. These systems should conform to NFPA 14, "Standard for the Installation of Standpipe and Hose Systems," for sizing, spacing, and pipe support requirements for Class III standpipes.
3.6.2 A capability shall be provided to ensure an adequate water flow rate and nozzle pressure for all hose stations. This capability includes the provision of hose station pressure reducers where	No similar requirement in Reg. Guide 1.189.

necessary for the safety of plant industrial fire brigade members and off-site fire department personnel.	
3.6.3 The proper type of hose nozzle to be supplied to each power block area shall be based on the area fire hazards. The usual combination spray/straight stream nozzle shall not be used in areas where the straight stream can cause unacceptable damage or present an electrical hazard to fire-fighting personnel. Listed electrically safe fixed fog nozzles shall be provided at locations where high-voltage shock hazards exist. All hose nozzles shall have shutoff capability and be able to control water flow from full open to full closed.	**3.4.1 Standpipes and Hose Stations** The proper type of hose nozzle to be supplied to each area should be based on the fire hazard analysis. The usual combination spray/straight-stream nozzle should not be used in areas where the straight stream can cause unacceptable mechanical damage. Fixed fog nozzles should be provided at locations where high-voltage shock hazards exist. All hose nozzles should have shutoff capability. Guidance on safe distances for water application to live electrical equipment may be found in the "NFPA Fire Protection Handbook," Chapter 6, Eighteenth Edition.
3.6.4 Provisions shall be made to supply water at least to standpipes and hose stations for manual fire suppression in all areas containing systems and components needed to perform the nuclear safety functions in the event of a safe shutdown earthquake (SSE). ~~*Exception: For existing plants that are not capable of meeting this requirement, provisions to restore a water supply and distribution system for manual fire-fighting purposes shall be made. This provisional manual fire-fighting standpipe/hose station system shall be capable of providing manual fire-fighting protection to the various plant locations important to supporting and maintaining the nuclear safety function. The provisions for establishing this provisional system shall be preplanned and be capable of being implemented in a timely manner following an SSE.*~~	**3.2.1 Fire Protection Water Supply** **(j)** Provisions should be made to supply water to at least two standpipes and hose connections for manual firefighting in areas containing equipment required for safe plant shutdown in the event of a safe shutdown earthquake. The piping system serving such hose stations should be analyzed for safe shutdown earthquake loading and should be provided with supports to ensure system pressure integrity. The piping and valves for the portion of hose standpipe system affected by this functional requirement should, as a minimum, satisfy ASME/ANSI B31.1. The water supply for this condition may be obtained by manual operator actuation of valves in a connection to the hose standpipe header from a normal seismic Category I water system such as the essential service water system. The cross connection should be (a) capable of providing flow to at least two hose stations [approximately 284 L/m (75 gpm) per hose station], and (b) designed to the same standards as the seismic Category I water system; it should not degrade the performance of the seismic Category I water system. **3.2.3 Fire Mains** **(e)** The fire main system piping is separate from service or sanitary water system piping, except as described in Regulatory Position 3.2.1 with regard to providing seismically designed water supply for standpipes and hose connections. **(i)** Sprinkler systems and manual hose station standpipes have connections to the yard main system so that a single active failure or a line break cannot impair both the primary and backup fire suppression systems. Alternatively, headers fed from each end are permitted inside buildings to supply both sprinkler and standpipe systems, provided steel piping and fittings meeting the

Comment: NRC has disallowed this exception during the rulemaking process.

	requirements of ASME/ANSI B31.1 are used for the headers up to and including the first valve supplying the sprinkler systems where such headers are part of the seismically analyzed hose standpipe system. When provided, such headers are considered an extension of the yard main system. Each sprinkler and standpipe system should be equipped with OS&Y (outside screw and yoke) gate valve or other approved shutoff valve and water flow alarm. **6.1.1.2 Containment Fire Suppression** The containment penetration of the standpipe system should meet the isolation requirements of GDC 56 of Appendix A to 10 CFR Part 50 and should be Seismic Category 1 and Quality Group B.
3.6.5 Where the seismic required hose stations are cross-connected to essential seismic non-fire protection water supply systems, the fire flow shall not degrade the essential water system requirement.	**3.2.1 Fire Protection Water Supply** **(j)** Provisions should be made to supply water to at least two standpipes and hose connections for manual firefighting in areas containing equipment required for safe plant shutdown in the event of a safe shutdown earthquake. The piping system serving such hose stations should be analyzed for safe shutdown earthquake loading and should be provided with supports to ensure system pressure integrity. The piping and valves for the portion of hose standpipe system affected by this functional requirement should, as a minimum, satisfy ASME/ANSI B31.1. The water supply for this condition may be obtained by manual operator actuation of valves in a connection to the hose standpipe header from a normal seismic Category I water system such as the essential service water system. The cross connection should be (a) capable of providing flow to at least two hose stations [approximately 284 L/m (75 gpm) per hose station], and (b) designed to the same standards as the seismic Category I water system; it should not degrade the performance of the seismic Category I water system.
3.7 Fire Extinguishers. Where provided, fire extinguishers of the appropriate number, size, and type shall be provided in accordance with NFPA 10, Standard for Portable Fire Extinguishers. Extinguishers shall be permitted to be positioned outside of fire areas due to radiological conditions.	**3.4.4 Fire Extinguishers** Fire extinguishers should be provided in areas that contain or could present a fire exposure hazard to equipment important to safety. Dry chemical extinguishers should be installed with due consideration given to possible adverse effects on equipment important to safety installed in the area. NFPA 10, "Standard for Portable Fire Extinguishers," provides guidance on the use and application of fire extinguishers.
3.8 Fire Alarm and Detection Systems. **3.8.1 Fire Alarm.**	**3.1.1 Fire Detection and Alarm Design Objectives and Performance Criteria**

Alarm initiating devices shall be installed in accordance with NFPA 72, National Fire Alarm Code®. Alarm annunciation shall allow the proprietary alarm system to transmit fire-related alarms, supervisory signals, and trouble signals to the control room or other constantly attended location from which required notifications and response can be initiated. Personnel assigned to the proprietary alarm station shall be permitted to have other duties. The following fire-related signals shall be transmitted: (1) Actuation of any fire detection device (2) Actuation of any fixed fire suppression system (3) Actuation of any manual fire alarm station (4) Starting of any fire pump (5) Actuation of any fire protection supervisory device (6) Indication of alarm system trouble condition	**(b)** Fire detection and alarm systems comply with the requirements of Class A systems as defined in NFPA 72, "National Fire Alarm Code," and Class I circuits as defined in NFPA 70. **(c)** Fire detectors are selected and installed in accordance with NFPA 72. Pre-operational and periodic testing of pulsed line-type heat detectors demonstrate that the frequencies used will not affect the actuation of protective relays in other plant systems. **(d)** Fire detection and alarm systems give audible and visible alarm and annunciation in the control room. Where zoned detection systems are used in a given fire area, local means are provided to identify which detector zone has actuated. **3.3.2 Fire Pumps** **(d)** Alarms or annunciators to indicate pump running, driver availability, failure to start, and low fire-main pressure are provided in the control room.
3.8.1.1 Means shall be provided to allow a person observing a fire at any location in the plant to quickly and reliably communicate to the control room or other suitable constantly attended location.	No similar requirement in Reg. Guide 1.189.
3.8.1.2 Means shall be provided to promptly notify the following of any fire emergency in such a way as to allow them to determine an appropriate course of action: (1) General site population in all occupied areas (2) Members of the industrial fire brigade and other groups supporting fire emergency response (3) Off-site fire emergency response agencies. Two independent means shall be available (e.g., telephone and radio) for notification of off-site emergency services	No similar requirement in Reg. Guide 1.189.
3.8.2 Detection. If automatic fire detection is required to meet the performance or deterministic requirements of Chapter 4, then these devices shall be installed in accordance with NFPA 72, National Fire Alarm Code, and its applicable appendixes.	**3.1.1 Fire Detection and Alarm Design Objectives and Performance Criteria** **(b)** Fire detection and alarm systems comply with the requirements of Class A systems as defined in NFPA 72, "National Fire Alarm Code," and Class I circuits as defined in NFPA 70. **(c)** Fire detectors are selected and installed in accordance

	with NFPA 72. Pre-operational and periodic testing of pulsed line-type heat detectors demonstrate that the frequencies used will not affect the actuation of protective relays in other plant systems.
3.9 Automatic and Manual Water-Based Fire Suppression Systems. **3.9.1*** If an automatic or manual water-based fire suppression system is required to meet the performance or deterministic requirements of Chapter 4, then the system shall be installed in accordance with the appropriate NFPA standards including the following: (1) NFPA 13, Standard for the Installation of Sprinkler Systems (2) NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection (3) NFPA 750, Standard on Water Mist Fire Protection Systems (4) NFPA 16, Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems	**3.3.1.1 Sprinkler and Spray Systems** Water sprinkler and spray suppression systems are the most widely used means of implementing automatic water-based fire suppression. Sprinkler and spray systems should, as a minimum, conform to requirements of appropriate standards such as NFPA 13 and NFPA15. **3.3.1.2 Water Mist Systems** Water mist suppression systems may be useful in specialized situations, particularly where the application of water needs to be restricted. Water mist systems should conform to appropriate standards such as NFPA 750, "Standard on Water Mist Fire Protection Systems." **3.3.1.3 Foam-Water Sprinkler and Spray Systems** Certain fires, such as those involving flammable liquids, respond well to foam suppression. Consideration should be given to the use of foam sprinkler and spray systems. Foam sprinkler and spray systems should conform to appropriate standards such as NFPA 16, "Standard for the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems," NFPA 16A, "Standard for the Installation of Closed-Head Foam-Water Sprinkler Systems," NFPA 11, "Standard for Low-Expansion Foam," and NFPA 11A, "Standard for Medium- and High-Expansion Foam Systems."
3.9.2 Each system shall be equipped with a water flow alarm.	**3.2.3 Fire Mains** **(i)** … Each sprinkler and standpipe system should be equipped with OS&Y (outside screw and yoke) gate valve or other approved shutoff valve and water flow alarm.
3.9.3 All alarms from fire suppression systems shall annunciate in the control room or other suitable constantly attended location.	No similar requirement in Reg. Guide 1.189.
3.9.4 Diesel-driven fire pumps shall be protected by automatic sprinklers.	No similar requirement in Reg. Guide 1.189.
3.9.5 Each system shall be equipped with an OS&Y gate valve or other approved shutoff valve.	**3.2.3 Fire Mains** **(i)** Each sprinkler and standpipe system should be equipped with OS&Y (outside screw and yoke) gate valve or other approved shutoff valve and water flow alarm.
3.9.6 All valves controlling water-based fire suppression systems required to meet the	**3.2.3 Fire Mains** **(d)** Control and sectionalizing valves in fire mains and water-based fire suppression systems are electrically

performance or deterministic requirements of Chapter 4 shall be supervised as described in 3.5.14.	supervised or administratively controlled (e.g., locked valves with key control, tamper-proof seals). The electrical supervision signal indicates in the control room. All valves in the fire protection system are periodically checked to verify position (see NFPA 25, "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems," for guidance).
3.10 Gaseous Fire Suppression Systems. **3.10.1** If an automatic total flooding and local application gaseous fire suppression system is required to meet the performance or deterministic requirements of Chapter 4, then the system shall be designed and installed in accordance with the following applicable NFPA codes: (1) NFPA 12, Standard on Carbon Dioxide Extinguishing Systems (2) NFPA 12A, Standard on Halon 1301 Fire Extinguishing Systems (3) NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems	**3.3.2 Gaseous Fire Suppression** Where total flooding gas extinguishing systems are used, area intake and exhaust ventilation dampers should be controlled in accordance with appropriate standards to maintain the necessary gas concentration. (See NFPA 12, "Standard on Carbon Dioxide Extinguishing Systems," NFPA 12A, "Standard on Halon 1301 Fire Extinguishing Systems," and NFPA 2001, "Standard on Clean Agent Fire Extinguishing Systems.") (Also see Regulatory Position 4.1.4.4.) **3.3.2.3 Clean Agents** Halon alternative (or "clean agent") fire extinguishing systems should comply with applicable standards such as NFPA 2001. Only listed or approved agents should be used. Provisions for locally disarming automatic systems should be key locked and under strict administrative control. Automatic extinguishing systems should not be disarmed unless controls as described in Regulatory Position 2.4 are provided. In addition to the guidelines of NFPA 2001, preventive maintenance and testing of the systems, including verifying agent quantity of the clean agent cylinders/containers, should be done. Particular consideration should also be given to: (a) The minimum required clean agent concentration, distribution, soak time, and ventilation control, (b) The toxicity of the clean agent, (c) The toxicity and corrosive characteristics of the thermal decomposition products of the clean agent, (d) Conflicting requirements for venting during clean agent injection to prevent over pressurization versus sealing to prevent the loss of agent, and (e) The effectiveness of the particular clean agent at its design concentration for the protected hazard. (f) The location and selection of the activating detectors.
3.10.2 Operation of gaseous fire suppression systems shall annunciate and alarm in the control room or other constantly attended location identified.	No similar requirement in Reg. Guide 1.189.
3.10.3 Ventilation system design shall take into account prevention from over-pressurization during agent	**3.3.2 Gaseous Fire Suppression** Where gas suppression systems are installed, openings in the area should be adequately sealed or the suppression

injection, adequate sealing to prevent loss of agent, and confinement of radioactive contaminants.	system should be sized to compensate for the loss of the suppression agent through floor drains and other openings. (Also see Regulatory Position 4.1.5.) Where total flooding gas extinguishing systems are used, area intake and exhaust ventilation dampers should be controlled in accordance with appropriate standards to maintain the necessary gas concentration. (See NFPA 12, "Standard on Carbon Dioxide Extinguishing Systems," NFPA 12A, "Standard on Halon 1301 Fire Extinguishing Systems," and NFPA 2001, "Standard on Clean Agent Fire Extinguishing Systems.") (Also see Regulatory Position 4.1.4.4.) The adequacy of gas suppression systems and protected area boundary seals to contain the gas suppressant should be tested as specified in the applicable NFPA Standards. **3.3.2.1 Carbon Dioxide (CO_2) Systems** Particular consideration should also be given to: **(a)** The minimum required CO_2 concentration, distribution, soak time, and ventilation control; **(d)** Conflicting requirements for venting during CO_2 injection to prevent over pressurization versus sealing to prevent loss of agent. **3.3.2.2 Halon** Particular consideration should also be given to: **(a)** The minimum required Halon concentration, distribution, soak time, and ventilation control.
3.10.4* In any area required to be protected by both primary and backup gaseous fire suppression systems, a single active failure or a crack in any pipe in the fire suppression system shall not impair both the primary and backup fire suppression capability.	No similar requirement in Reg. Guide 1.189.
3.10.5 Provisions for locally disarming automatic gaseous suppression systems shall be secured and under strict administrative control.	**3.3.2.1 Carbon Dioxide (CO_2) Systems** Provisions for locally disarming automatic carbon dioxide systems should be key locked and under strict administrative control. Automatic carbon dioxide extinguishing systems should not be disarmed unless controls as described in Regulatory Position 2.4 are provided. **3.3.2.2 Halon** Provisions for locally disarming automatic Halon systems should be key locked and under strict administrative control. Automatic Halon extinguishing systems should not be disarmed unless controls as described in Regulatory Position 2.4 are provided. **3.3.2.3 Clean Agents** Provisions for locally disarming automatic systems should be key locked and under strict administrative

	control. Automatic extinguishing systems should not be disarmed unless controls as described in Regulatory Position 2.4 are provided.
3.10.6* Total flooding carbon dioxide systems shall not be used in normally occupied areas.	**6.1.2 Control Room Complex** Ventilation system openings between the control room and peripheral rooms should have automatic smoke dampers that close on operation of the fire detection or suppression system. If a gas extinguishing system is used for fire suppression, these dampers should be strong enough to support the pressure rise accompanying the agent discharge and seal tightly against infiltration of the agent into the control room. Carbon dioxide total flooding systems are not acceptable for these areas.
3.10.7 Automatic total flooding carbon dioxide systems shall be equipped with an audible pre-discharge alarm and discharge delay sufficient to permit egress of personnel. The carbon dioxide system shall be provided with an odorizer.	**3.3.2.1 Carbon Dioxide (CO_2) Systems** Where automatic carbon dioxide systems are used, they should be equipped with a pre-discharge alarm system and a discharge delay to permit personnel egress.
3.10.8 Positive mechanical means shall be provided to lock out total flooding carbon dioxide systems during work in the protected space.	**3.3.2.1 Carbon Dioxide (CO_2) Systems** Provisions for locally disarming automatic carbon dioxide systems should be key locked and under strict administrative control. Automatic carbon dioxide extinguishing systems should not be disarmed unless controls as described in Regulatory Position 2.4 are provided.
3.10.9 The possibility of secondary thermal shock (cooling) damage shall be considered during the design of any gaseous fire suppression system, but particularly with carbon dioxide.	**3.3.2.1 Carbon Dioxide (CO_2) Systems** Particular consideration should also be given to: **(c)** The possibility of secondary thermal shock (cooling) damage.
3.10.10 Particular attention shall be given to corrosive characteristics of agent decomposition products on safety systems.	**3.3.2.2 Halon** Particular consideration should also be given to: **(c)** The toxicity and corrosive characteristics of the thermal decomposition products of Halon. **3.3.2.3 Clean Agents** Particular consideration should also be given to: **(c)** The toxicity and corrosive characteristics of the thermal decomposition products of the clean agent.
3.11 Passive Fire Protection Features.	
This section shall be used to determine the design and installation requirements for passive protection features. Passive fire protection features include wall, ceiling, and floor assemblies, fire doors, fire dampers, and through fire barrier penetration seals. Passive fire protection features also include electrical raceway fire barrier systems (ERFBS) that are provided to	

protect cables and electrical components and equipment from the effects of fire.	
3.11.1 Building Separation. Each major building within the power block shall be separated from the others by barriers having a designated fire resistance rating of 3 hours or by open space of at least 50 ft (15.2 m) or space that meets the requirements of NFPA 80A, Recommended Practice for Protection of Buildings from Exterior Fire Exposures. *Exception: Where a performance-based analysis determines the adequacy of building separation, the requirements of 3.11.1 shall not apply.*	**2.1.4 External/Exposure Fire Hazards** When a structure, system or component important to safety is near installations, such as flammable liquid or gas storage, the risk of exposure fires (originating in such installations) to the structures, systems, and components should be evaluated and appropriate protective measures taken. NFPA 80A, "Recommended Practice for Protection of Buildings from Exterior Fire Exposures," provides guidance on such exposure protection. **7.2 Turbine/Generator Building** The turbine building should be separated from adjacent structures containing equipment important to safety by a fire barrier with a rating of at least 3 hours. The fire barriers should be designed to maintain structural integrity even in the event of a complete collapse of the turbine structure. **7.3 Station Transformers** Transformers installed inside fire areas containing systems important to safety should be of the dry type or insulated and cooled with noncombustible liquid. Transformers filled with combustible fluid that are located indoors should be enclosed in a transformer vault. Additional guidance is provided in NFPA 70. Outdoor oil-filled transformers should have oil spill confinement features or drainage away from the buildings. Such transformers should be located at least 15.2 m (50 ft) distant from the building, or building walls within 15.2 m (50 ft) of oil-filled transformers should be without openings and have a fire resistance rating of at least 3 hours. **7.4 Diesel Fuel Oil Storage Areas** Diesel fuel oil tanks with a capacity greater than 4164 L (1,100 gallons) should not be located inside buildings containing equipment important to safety. If above-ground tanks are used, they should be located at least 15.2 m (50 ft) from any building containing equipment important to safety, or if located within 15.2 m (50 ft), they should be housed in a separate building with construction having a minimum fire resistance rating of 3 hours.
3.11.2 Fire Barriers. Fire barriers required by Chapter 4 shall include a specific fire-resistance rating. Fire barriers shall be designed and installed to meet the specific fire resistance rating using assemblies qualified by fire tests. The qualification fire tests shall be in accordance with NFPA 251, Standard Methods of	**1.4 Fire Test Reports and Fire Data** NFPA 251, "Standard Methods of Tests of Fire Endurance of Building Construction and Materials," advises that the test conditions should be evaluated carefully because variations from the construction of the test specimen or from the condition in which it is tested may substantially change the performance characteristics

Tests of Fire Endurance of Building Construction and Materials, or ASTM E 119, Standard Test Methods for Fire Tests of Building Construction and Materials.	of the tested assembly. Relative to testing of fire barrier assemblies, not all possible configurations can be tested, and additional guidance is provided in Regulatory Positions 1.8.3 and 4.2 of this guide for evaluation of installed configurations that deviate from tested conditions. **4.2.1.5 Testing and Qualification** **(a) Structural Fire Barriers** The design adequacy of fire barrier walls, floors, ceilings, and enclosures should be verified by fire endurance testing. NRC fire protection guidance refers to the guidance of NFPA 251 and ASTM E-119, "Standard Test Methods for Fire Tests of Building Construction and Materials," as acceptable test methods for demonstrating fire endurance performance. The guidance of NFPA 251 and ASTM E-119 should be consulted with regard to construction, materials, workmanship, and details such as dimensions of parts and the size of the specimens to be tested. In addition, NFPA 251 and ASTM E-119 should be consulted with regard to the placement of thermocouples on the specimen. **(b) Penetration Fire Barriers** Penetration fire barriers should be qualified by tests conducted by an independent testing authority in accordance with the provisions of NFPA 251 and ASTM E-119, "Standard Test Methods for Fire Tests of Building Construction and Materials." In addition, ASTM E-814, "Standard Test Method for Fire Tests of Through-Penetration Fire Stops," or IEEE Standard 634, "Standard Cable Penetration Fire Stop Qualification Test," could be used in development of a standard fire test. **Glossary** **Fire Resistance Rating** — The time that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251.
3.11.3* Fire Barrier Penetrations. Penetrations in fire barriers shall be provided with listed fire-rated door assemblies or listed rated fire dampers having a fire resistance rating consistent with the designated fire resistance rating of the barrier as determined by the performance requirements established by Chapter 4. (See 3.11.3.4 for penetration seals for through penetration fire stops.) Passive fire protection devices such as doors and dampers shall conform with the following NFPA standards, as applicable:	**4.2.1.2 Fire Doors** Additional guidance for fire doors is provided in NFPA 80, "Standard for Fire Doors and Fire Windows." **4.1.4.4 Fire Dampers** Redundant safe shutdown components may be separated by fire-resistant walls, floors, enclosures, or other types of barriers. For the fire barriers to be effective in limiting the propagation of fire, ventilation duct penetrations of fire barriers should be protected by means of fire dampers that are arranged to automatically close in the event of fire. Additional guidance is provided in NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems." (Also see

(1) NFPA 80, Standard for Fire Doors and Fire Windows (2) NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems (3) NFPA 101, Life Safety Code *Exception: Where fire area boundaries are not wall-to-wall, floor-to-ceiling boundaries with all penetrations sealed to the fire rating required of the boundaries, a performance-based analysis shall be required to assess the adequacy of fire barrier forming the fire boundary to determine if the barrier will withstand the fire effects of the hazards in the area. Openings in fire barriers shall be permitted to be protected by other means as acceptable to the AHJ.*	Regulatory Position 4.2.1.3.) **4.2.1.3 Fire Dampers** Building design should ensure that ventilation openings are properly protected. These openings should be protected with fire dampers that have been fire tested. In addition, the construction and installation techniques for ventilation openings through fire barriers should be qualified by fire endurance tests. For ventilation ducts that penetrate or terminate at a fire wall, guidance in NFPA 90A indicates that ventilation fire dampers should be installed within the fire wall penetration for barriers with a fire rating greater than or equal to 2 hours. NFPA 90A requires that fire dampers be installed in all air transfer openings within a rated wall. **4.1.2.1 Fire Areas** Where fire area boundaries are not 3-hour rated, or not wall-to-wall or floor-to-ceiling boundaries with all penetrations sealed to the fire rating of the boundaries, an evaluation should be performed to assess the adequacy of the fire area boundaries (i.e., barriers) to determine whether the boundaries will withstand the hazards associated with the area and, as necessary, protect important equipment within the area from a fire outside the area. Unsealed openings should be identified and considered when evaluating the overall effectiveness of the barrier (See Regulatory Position 1.4.3 for positions related to barrier evaluations. See Regulatory Position 4.2.1 for positions related to fire barrier testing and acceptance.)
3.11.4* Through Penetration Fire Stops. Through penetration fire stops for penetrations such as pipes, conduits, bus ducts, cables, wires, pneumatic tubes and ducts, and similar building service equipment that pass through fire barriers shall be protected as follows. (a) The annular space between the penetrating item and the through opening in the fire barrier shall be filled with a qualified fire-resistive penetration seal assembly capable of maintaining the fire resistance of the fire barrier. The assembly shall be qualified by tests in accordance with a fire test protocol acceptable to the AHJ or be protected by a listed fire-rated device for the specified fire-resistive period. (b) Conduits shall be provided with an internal fire seal that has an equivalent fire-resistive rating to that of the fire barrier through opening fire stop and shall	**4.2.1 Structural Fire Barriers** Fire barriers are those components of construction (walls, floors, and their supports), including beams, joists, columns, penetration seals or closures, fire doors, and fire dampers that are rated by approving laboratories in hours of resistance to fire and are used to prevent the spread of fire. **4.2.1.1 Wall, Floor, and Ceiling Assemblies** Building design should ensure that openings through fire barriers are properly protected. Openings through fire barriers that separate fire areas should be sealed or closed to provide a fire resistance rating at least equal to that required of the barrier itself. The construction and installation techniques for penetrations through fire barriers should be qualified by fire endurance tests (see Regulatory Position 4.2.1.5, Testing and Qualification). **4.2.1.2 Fire Doors** Building design should ensure that door openings are properly protected. These openings should be protected with fire doors that have been qualified by a fire test.

be permitted to be installed on either side of the barrier in a location that is as close to the barrier as possible. *Exception: Openings inside conduit 4 in. (10.2 cm) or less in diameter shall be sealed at the fire barrier with a fire-rated internal seal unless the conduit extends greater than 5 ft (1.5 m) on each side of the fire barrier. In this case the conduit opening shall be provided with noncombustible material to prevent the passage of smoke and hot gases. The fill depth of the material packed to a depth of 2 in. (5.1 cm) shall constitute an acceptable smoke and hot gas seal in this application.*	The construction and installation techniques for doors and door openings through fire barriers should be in accordance with the door manufacturer's recommendations and the tested configuration. **4.2.1.3 Fire Dampers** Building design should ensure that ventilation openings are properly protected. These openings should be protected with fire dampers that have been fire tested. In addition, the construction and installation techniques for ventilation openings through fire barriers should be qualified by fire endurance tests. For ventilation ducts that penetrate or terminate at a fire wall, guidance in NFPA 90A indicates that ventilation fire dampers should be installed within the fire wall penetration for barriers with a fire rating greater than or equal to 2 hours. NFPA 90A requires that fire dampers be installed in all air transfer openings within a rated wall. **4.2.1.4 Penetration Seals** Openings through fire barriers for pipe, conduit, and cable trays that separate fire areas should be sealed or closed to provide a fire resistance rating at least equal to that required of the barrier itself. Openings inside conduit larger than 102 mm (4 inches) in diameter should be sealed at the fire barrier penetration. Openings inside conduit 102 mm (4 inches) or less in diameter should be sealed at the fire barrier unless the conduit extends at least 1.5 m (5 feet) on each side of the fire barrier and is sealed either at both ends or at the fire barrier with material to prevent the passage of smoke and hot gases. Fire barrier penetrations that maintain environmental isolation or pressure differentials should be qualified by test to maintain the barrier integrity under such conditions.
3.11.5* Electrical Raceway Fire Barrier Systems (ERFBS). ERFBS required by Chapter 4 shall be capable of resisting the fire effects of the hazards in the area. ERFBS shall be tested in accordance with and shall meet the acceptance criteria of NRC Generic Letter 86-10, Supplement 1, "Fire Endurance Test Acceptance Criteria for Fire Barrier Systems Used to Separate Safe Shutdown Trains Within the Same Fire Area." The ERFBS needs to adequately address the design requirements and limitations of supports and intervening items and their impact on the fire barrier system rating. The fire barrier system's ability to maintain the required nuclear safety circuits free of fire	**4.2.3.1 Electrical Raceway Fire Barrier Systems** Redundant cable systems important to safety should be separated from each other and from potential fire exposure hazards in non-safety-related areas in accordance with the separation means of Regulatory Position 5.5.a-c. For areas where separation of electrical circuits important to safe shutdown cannot be accomplished via rated structural fire barriers, cable protection assemblies have been applied to conduit and cable trays to meet 1-hour and 3-hour separation requirements. The design of fire barriers for horizontal and vertical cable trays should meet the requirements of ASTM E119, including a hose stream test. The acceptance criteria for

damage for a specific thermal exposure, barrier design, raceway size and type, cable size, fill, and type shall be demonstrated. ***Exception No. 1**: When the temperatures inside the fire barrier system exceed the maximum temperature allowed by the acceptance criteria of Generic Letter 86-10, "Fire Endurance Acceptance Test Criteria for Fire Barrier Systems Used to Separate Redundant Safe Shutdown Training Within the Same Fire Area," Supplement 1, functionality of the cable at these elevated temperatures shall be demonstrated. Qualification demonstration of these cables shall be performed in accordance with the electrical testing requirements of Generic Letter 86-10, Supplement 1, Attachment 1, "Attachment Methods for Demonstrating Functionality of Cables Protected by Raceway Fire Barrier Systems During and After Fire Endurance Test Exposure."* ***Exception No. 2**: ERFBS systems employed prior to the issuance of Generic Letter 86-10, Supplement 1, are acceptable providing that the system successfully met the limiting end point temperature requirements as specified by the AHJ at the time of acceptance.*	raceway fire barriers is discussed in Regulatory Position 4.3.2 to this guide. **4.3.1 Electrical Raceway Fire Barrier Systems: General Guidelines** Fire barriers relied upon to protect shutdown-related systems and to meet the separation means of Regulatory Position 5.5 should have a fire rating of either 1 or 3 hours. Fire rating is defined as the endurance period of a fire barrier or structure; it defines the period of resistance to a standard fire exposure before the first critical point in behavior is observed. Fire endurance ratings of building construction and materials are demonstrated by testing fire barrier assemblies in accordance with the provisions of the applicable sections of NFPA 251 and ASTM E-119. Assemblies that pass specified acceptance criteria (e.g., standard time-temperature fire endurance exposure, unexposed side temperature rise, and hose stream impingement) are considered to have a specific fire resistance rating. The basic premise of the fire resistance criteria is that fire barriers that do not exceed 181°C [325°F] cold side temperature[2] and pass the hose stream test provide reasonable assurance that the shutdown capability is protected without further analyses. If the temperature criterion is exceeded, sufficient additional information is needed to perform an engineering evaluation to demonstrate that the shutdown capability is protected. **4.3.2 Fire Endurance Test Acceptance Criteria for Electrical Raceway and Component Fire Barrier Systems for Separating Safe Shutdown Functions Within the Same Fire Area** The fire endurance qualification test for fire barrier materials applied directly to a raceway or component is considered to be successful if all three of the following conditions are met. **(1)** The average unexposed side temperature of the fire barrier system, as measured on the exterior surface of the raceway or component, did not exceed 139°C [250°F] above its initial temperature; and (NFPA 251 and ASTM E-119 allow this temperature to be determined by averaging thermocouple temperature readings. For the purposes of this criterion, thermocouple averaging can be used provided similar series of thermocouples (e.g., cable tray side rail) are

[2]The 181°C [325°F] temperature condition was established by allowing the temperature of the unexposed side of the fire barrier to rise 139°C [250°F] above the assumed 24°C [75°F] ambient air temperature, as measured by the thermocouples within the test specimen at the onset of the fire exposure during the fire test.

	averaged together to determine temperature performance of the raceway fire barrier system. In addition, conditions of acceptance are placed on the temperatures measured by a single thermocouple. If any single thermocouple exceeds 30 percent of the maximum allowable temperature rise (i.e., 139°C + 42°C = 181°C [250°F + 75°F = 325°F]), the test exceeded the temperature criteria limit.) **(2)** Irrespective of the unexposed side temperature rise during the fire test, if cables or components are included in the fire barrier test specimen, a visual inspection is performed.[3] Cables should not show signs of degraded conditions[4] resulting from the thermal effects of the fire exposure; and (When signs of thermal degradation are present, the fire barrier did not perform its intended fire-resistive function. For barriers that are not capable of performing their intended function, an engineering analysis that demonstrates that the functionality of thermally degraded cables or components was maintained and that the cables or components would have adequately performed their intended function during and after a postulated fire exposure should be performed. A methodology for demonstrating the functionality of cables during and after a fire test exposure is provided below. The purpose of the functionality tests is to justify observed deviations in fire barrier performance. For fire barrier test specimens that are tested without cables, an engineering analysis justifying internal fire barrier temperature conditions greater than allowed can be based on a comparison of the fire barrier internal temperature profile measured during the fire endurance test to existing cable specific performance data, such as environmental qualification (EQ) tests.) **(3)** The cable tray, raceway, or component fire barrier system remained intact during the fire exposure and water hose stream test without developing any openings through which the cable tray, raceway, or component

[3]When the temperature criteria are exceeded or damage occurs, component operability at the temperatures experienced during the fire test should be assessed. Fire endurance tests that are judged acceptable on the basis of a visual inspection of specific components or cables included in the test specimen may not be applied to other components or cables without a specific evaluation.

[4]Examples of thermal cable degradation are jacket swelling, splitting, cracking, blistering, melting, or discoloration; shield exposed; conductor insulation exposed, degraded, or discolored; bare copper conductor exposed.

[5]For the thermocouples installed on conduits, cable tray side rails, and bare copper conductors, a +13 mm [+ ½ inch] installation tolerance is acceptable.

[6] The review guidance for Megger and Hi-Pot test voltages was derived from IEEE 383-1974 and IEEE 690-1984.

[7] A Megger test voltage of 1000 V dc is acceptable provided a Hi-Pot test is performed after the Megger test for power cables rated at less than 1000 V ac.

	(e.g., cables) is visible. (See Regulatory Position 4.3.3 regarding acceptable hose stream test methods.) The test specimen should be representative of the construction for which the fire rating is desired as to materials, workmanship, and details such as dimensions of parts, and should be built under representative conditions. Raceway fire barrier systems being subjected to qualification fire endurance tests should be representative of the end use. For example, if it is intended to install a cable tray fire barrier system in the plant without protecting the cable tray supports, the test program should duplicate these field conditions. In addition, the fire test program should encompass or bound raceway sizes and the various configurations for those fire barrier systems installed in the plant. It should be noted that several test specimens will be required in order to qualify various sizes of horizontal and vertical runs of cable trays and conduits, junction boxes and pull boxes, etc. The cable tray or raceway design used for the tests should be constructed with materials and configurations representative of in-plant conditions (e.g., the mass associated with typical steel conduits and cable trays, representative internal and external penetration seals). If cables are included in the raceway fire barrier test specimen, these cables should be representative of the installed plant-specific cables. Measuring cable temperatures is not a reliable means for determining excessive temperature conditions that may occur at any point along the length of the cable during the fire test. In lieu of measuring the unexposed surface temperature of the fire barrier test specimen, methods that will measure the surface temperature of the raceway (e.g., exterior of the conduit, side rails of cable trays, bottom and top of cable tray surfaces, junction box external surfaces) can be considered as equivalent if the raceway components used to construct the fire test specimen represent plant-specific components and configurations. The metal surfaces of the raceway, under fire test conditions, exhibit good thermal conductivity properties. Temperatures measured on these surfaces provide an indication of the actual temperature rise within the fire barrier system. In 1979, American Nuclear Insurers (ANI) issued a fire endurance test method for raceway fire barrier systems for insurance purposes. This method, "Fire Endurance Protective Envelope Systems for Class 1E Electrical Circuits" (ANI Test), specified that cable temperatures be monitored by thermocouples. Since cable jackets have a low thermal conductivity, the actual local temperatures

	of the cable jackets' indications of barrier failure and internal fire barrier temperature rise conditions during the fire exposure are masked. Monitoring cable temperatures can give indications of low internal fire barrier temperature conditions during the fire endurance test. Using this temperature monitoring approach, cable damage can occur without indication of excessive temperatures on the cables. This, linked with no loss of circuit integrity, would give indications of a successful test. The staff considers monitoring the cable temperature as the primary means of determining cable tray or raceway fire barrier performance to be nonconservative. Therefore, the staff has incorporated the provision for a post-fire visual inspection of cables that are installed in fire barrier test specimens. As discussed above, temperatures monitored on the exterior surface of the raceway provide a more representative indication of fire barrier performance. Fire endurance tests of raceway fire barrier systems should be without cables. This method is preferred because by excluding cables from the test specimen it eliminates bias in the test results created by the thermal mass of the cables. Without this thermal mass, the internal temperature conditions measured by the test specimen thermocouples during the fire exposure will provide a more accurate determination of fire barrier thermal performance. **4.3.2.1 Thermocouple Placement — Test Specimens Containing Cables** The following are acceptable placements of thermocouples for determining the thermal performance of raceway or cable tray fire barrier systems that contain cables during the fire exposure. **(a) Conduits** — The temperature rise on the unexposed surface of a fire barrier system installed on a conduit should be measured by placing the thermocouples every 152 mm [6 inches][5] on the exterior conduit surface underneath the fire barrier material. The thermocouples should be attached to the exterior conduit surface located opposite the test deck and closest to the furnace fire source. Thermocouples should also be placed immediately adjacent to all structural members, supports, and barrier penetrations. **(b) Cable Trays** — The temperature rise on the unexposed surface of a fire barrier system installed on a cable tray should be measured by placing the thermocouples on the exterior surface of the tray side rails between the cable tray side rail and the fire barrier

	material. In addition to placing thermocouples on the side rails, thermocouples should be attached to two AWG 8 stranded bare copper conductors. The first copper conductor should be installed on the bottom of the cable tray rungs along the entire length and down the longitudinal center of the cable tray run. The second conductor should be installed along the outer top surface of the cables closest to the top and toward the center of the fire barrier. Thermocouples should be placed every 152 mm (6 inches) down the longitudinal center along the outside surface of the cable tray side rails and along the bare copper conductors. Thermocouples should also be placed immediately adjacent to all structural members, supports, and barrier penetrations. **(c) Junction Boxes (JBs)** — The temperature rise on the unexposed surface of a fire barrier system installed on junction boxes should be measured by placing thermocouples on either the inside or the outside of each JB surface. Each JB surface or face should have a minimum of one thermocouple, located at its geometric center. In addition, one thermocouple should be installed for every one square foot of JB surface area. These thermocouples should be located at the geometric centers of the one square foot areas. At least one thermocouple should also be placed within 25 mm (1 inch) of each penetration connector/interface. **(d) Airdrops** — The internal airdrop temperatures should be measured by thermocouples placed every 305 mm (12 inches) on the cables routed within the air drop and by a stranded AWG 8 bare copper conductor routed inside and along the entire length of the airdrop system with thermocouples installed every 152 mm (6 inches) along the length of the copper conductor. The copper conductor should be in close proximity with the unexposed surface of the fire barrier material. Thermocouples should also be placed immediately adjacent to all supports and barrier penetrations. **4.3.2.2 Thermocouple Placement -- Test Specimens Without Cables** The following are acceptable thermocouple placements for determining the thermal performance of raceway or cable tray fire barrier systems that do not contain cables. **(a) Conduits** — The temperature rise of the unexposed surface of a fire barrier system installed on a conduit should be measured by placing thermocouples every 152 mm [6 inches] on the exterior conduit surface between the conduit and the unexposed surface of the fire barrier material. These thermocouples should be attached to the exterior conduit surface opposite the test deck and closest

	to the furnace fire source. The internal raceway temperatures should be measured by a stranded AWG 8 bare copper conductor routed through the entire length of the conduit system with thermocouples installed every 152 mm [6 inches] along the length of the copper conductor. Thermocouples should also be placed immediately adjacent to all structural members, supports, and barrier penetrations. **(b) Cable Trays** — The temperature rise on the unexposed surface of a fire barrier system installed on a cable tray should be measured by placing thermocouples every 152 mm [6 inches] on the exterior surface of each tray side rails between the side rail and the fire barrier material. Internal raceway temperatures should be measured by a stranded AWG 8 bare copper conductor routed on the top of the cable tray rungs along the entire length and down the longitudinal center of the cable tray run with thermocouples installed every 152 mm [6 inches] along the length of the copper conductor. Thermocouples should be placed immediately adjacent to all structural members, supports, and barrier penetrations. **(c) Junction Boxes** — The temperature rise on the unexposed surface of a fire barrier system installed on junction boxes (JBs) should be measured by placing thermocouples on either the inside or the outside of each JB surface. Each JB surface or face should have a minimum of one thermocouple, located at its geometric center. In addition, one thermocouple should be installed for every one square foot of JB surface area. These thermocouples should be located at the geometric centers of the one square foot areas. At least one thermocouple should also be placed within 25 mm [1 inch] of each penetration connector/interface. **(d) Airdrops** — The internal airdrop temperatures should be measured by a stranded AWG 8 bare copper conductor routed inside and along the entire length of the airdrop system with thermocouples installed every 152 mm [6 inches] along the length of the copper conductor. The copper conductor should be in close proximity with the unexposed surface of the fire barrier material. Thermocouples should also be placed immediately adjacent to all supports and penetrations. **4.3.2.3 Criteria for Averaging Temperatures** Temperature conditions on the unexposed surfaces of the fire barrier material during the fire test will be determined by averaging the temperatures measured by the thermocouples installed in or on the raceway. In determining these temperature conditions, the

	thermocouples measuring similar areas of the fire barrier should be averaged together. Acceptance will be based on the individual averages. The following methods of averaging should be followed. **(a) Conduits** — The thermocouples applied to the outside metal surface of the conduit should be averaged together. **(b) Cable Trays** — The thermocouples on each cable tray side rail should be averaged separately. For example, thermocouples placed on one side rail will be averaged separately from the other side rail. In addition, the temperature conditions measured by thermocouples on the bare copper conductor should be averaged separately from the side rails. **(c) Junction Boxes** — For JBs that have only one thermocouple on each JB surface, the individual JB surface thermocouples should be averaged together. For JBs that have more than one thermocouple on each JB surface, the thermocouples on the individual JB surfaces should be averaged together. **(d) Airdrops** — The thermocouples placed on the copper conductor within the airdrop fire barrier should be averaged together. The average of any thermocouple group should not exceed 139°C [250°F] above the unexposed side temperature within the fire barrier test specimen at the onset of the fire endurance test. In addition, the temperature of each individual thermocouple will be evaluated. Individual thermocouple conditions should not exceed the 139°C [250°F] temperature rise by more than 30 percent (i.e., 181°C [375°F]). If a fire barrier test specimen without cables does not meet the average or maximum single point temperature criteria, the internal raceway temperature profile as measured by the instrumented bare copper conductors during the fire exposure can be used to assess cable functionality through air oven tests of plant specific cable types and construction, as discussed below. **4.3.3 Hose Stream Tests** NFPA 251 and ASTM E-119 allow flexibility in hose stream testing. The standards allow the hose stream test to be performed on a duplicate test specimen subjected to a fire endurance test for a period equal to one-half of that indicated as the fire resistance rating, but not for more than 1 hour (e.g., 30-minute fire exposure to qualify a 1-hour fire rated barrier). For safe shutdown-related fire barrier systems and duplicate electrical cable tray or raceway and component fire barrier test specimens that have been exposed to the

	½-duration test fire exposure, the staff finds the hose stream application specified by NFPA 251 acceptable. NFPA 251 requires the stream of water to be delivered through a 64-mm [2½-inch] hose discharging through a standard 29-mm [1½-inch] playpipe nozzle onto the test specimen after the fire exposure test. The stream is applied with the nozzle orifice positioned 6.1 meters [20 feet] away from the center of the test specimen at a pressure of 207 kPa [30 psi]. The application of the stream is to all exposed parts of the specimen for a duration of at least 1 minute for a 1-hour barrier and 2½ minutes for a 3-hour barrier. As an alternative for electrical raceway fire barrier test specimens, the application of the hose stream test can be performed immediately after the completion of the full fire endurance test period. If this method is used to satisfy the hose stream test criteria, any one of the following hose stream applications is acceptable. • The stream applied at random to all exposed surfaces of the test specimen through a 64-mm [2½-inch] national standard playpipe with a 29-mm [1½- inch] orifice at a pressure of 207 kPa [30 psi] at a distance of 6.1 meters [20 feet] from the specimen. (Durations of the hose stream applications — 1 minute for a 1-hour barrier and 2½ minutes for a 3-hour barrier.) or • The stream applied at random to all exposed surfaces of the test specimen through a 38-mm [1½-inch] fog nozzle set at a discharge angle of 30 degrees with a nozzle pressure of 517 kPa [75 psi] and a minimum discharge of 284 lpm [75 gpm] with the tip of the nozzle at a maximum of 1.5 meters [5 feet] from the test specimen. (Duration of the hose stream application — 5 minutes for both 1-hour and 3-hour barriers.) or • The stream applied at random to all exposed surfaces of the test specimen through a 38-mm [1½-inch] fog nozzle set at a discharge angle of 15 degrees with a nozzle pressure of 517 kPa [75 psi] and a minimum discharge of 284 lpm [75 gpm] with the tip of the nozzle at a maximum of 3 meters [10 feet] from the test specimen. (Duration of the hose stream application — 5 minutes for both 1-hour and 3-hour barriers.) **4.3.4 Demonstrating Functionality of Cables Protected by Raceway Fire Barrier Systems During and After Fire Endurance Test Exposure** During fire tests of raceway fire barrier systems, thermal damage to the cables has led to cable jacket and insulation degradation without the loss of circuit integrity as monitored using ANI criteria (applied voltage of 8 to 10 volts dc). Since cable voltages used for ANI circuit

	integrity tests do not replicate cable operating voltages, loss of cable insulation conditions can exist during the fire test without a dead short occurring. It is expected that if the cables were at rated power and current, a fault would propagate. The use of circuit integrity monitoring during the fire endurance test is not a valid method for demonstrating that the protected shutdown circuits are capable of performing their required function during and after the test fire exposure. Therefore, circuit integrity monitoring using the ANI criteria is not required to satisfy NRC acceptance criteria for fire barrier qualification. The following approaches are acceptable for evaluation of cable functionality. **4.3.4.1 Use of Environmental Qualification Data** Comparison of the fire barrier internal time-temperature profile measured during the fire endurance test to existing cable performance data, such as data from environmental qualification (EQ) tests, could be proposed to the staff as a method for demonstrating cable functionality. EQ testing is typically performed to rigorous conditions, including rated voltage and current. By correlating the EQ test time-temperature profile to the fire test time-temperature profile, the EQ test data would provide a viable mechanism to ensure cable functionality. A large body of EQ test data for many cable types exists today. The use of EQ data represents a cost-effective approach for addressing cable functionality for fire tests for those cases where the 181°C [325°F] limit is exceeded. A comparison of fire test temperature profiles to existing EQ and loss-of-coolant accident (LOCA) test results or air oven test results is an acceptable approach to demonstrate cable functionality provided the subject analysis incorporates the anticipated temperature rise that is due to self heating effects of installed power cables with the fire test results. **4.3.4.2 Cable Insulation Tests** The two principal materials used as cable insulation and cable jackets by the nuclear industry are thermoplastics and thermosetting polymeric materials. A thermoplastic material can be softened and re-softened by heating and reheating. Conversely, thermosetting cable insulation materials cure by chemical reaction and do not soften when heated. Under excessive heating thermosetting insulation becomes stiff and brittle. Electrical faults may be caused by softening and flowing of thermoplastic insulating materials at temperatures as low as 149°C [300°F]. Thermosetting electrical conductor insulation materials usually retain their electrical properties under short-term exposures to temperatures as high as 260°C

	[500°F]. Insulation resistance (Megger) tests provide indications of the condition of the cable insulation resistance, whereas the high potential (Hi-Pot) test provides assurance that the cable has sufficient dielectric strength to withstand the applied rated voltage. A cable insulation failure usually results from two breakdown modes: One failure mode is excessive dielectric loss that is due to low insulation resistance, and the other failure mode is overpotential stress that is due to loss of dielectric strength of the insulation material. To provide reasonable assurance that the cables would have functioned during and after the fire exposure, Megger tests need to be performed before the fire test, at multiple time intervals during the fire exposure (i.e., every 20 minutes during the 1-hour fire test and every hour during the 3-hour fire test) for instrumentation cables only, and immediately after the fire endurance test to assess the cable insulation resistance levels. This testing will assure that the cables will maintain the insulation resistance levels necessary for proper operation of instruments. The Megger tests (pre-fire, during the fire [if performed], and immediately after the fire test conditions) should be done conductor-to-conductor for multi-conductor and conductor-to-ground for all cables. The minimum acceptable insulation resistance (IR) value, using the test voltage values as shown in the table below, is determined by using the following expression: IR (Mega-ohms) = {[K+1 Mega-ohm] * 1000 (ft) } / Length (ft) Where K = 1 Mega-ohm/KV * Operating Voltage (expressed in KV) In addition, to determine the insulation resistance levels required for nuclear instrumentation cables, an assessment of the minimum insulation resistance value (e.g., one mega-ohm) and its potential impact on the functionality of these cables should be evaluated. An ac or dc high potential (Hi-Pot) test for power cables greater than 1000 volts (V) should also be performed after the post-fire Megger tests to assess the dielectric strength. This test provides assurance that the cable will withstand the applied voltage during and after a fire. The high potential test should be performed for a 5 minute duration at 60 percent of either 80 V/mil ac or 240 V/mil dc (e.g., 125 mil conductor insulation thickness x 240 V/mil dc x 0.6 = 18,000 V dc). The table below summarizes the Megger and Hi-Pot test voltages[6] that, when applied to power, control, and instrumentation cables, would constitute an acceptable

cable functionality test.

TYPE	OPERATING VOLTAGE	MEGGER TEST VOLTAGE	HIGH POTENTIAL TEST VOLTAGE
Power	>1000 V ac	2500 V dc	60% x 80 V/mil (ac) 60% x 240 V/mil (dc)
Power	<1000 V ac	1500 V dc[7]	None
Instrument and Control	<250 V dc <120 V ac	500 V dc	None

The electrical cable functionality tests recommended above are one acceptable method. Alternative methods to assess degradation of cable functionality will be evaluated on a case-by-case basis. The above table summarizing the Megger and Hi-Pot test voltages are "typical" and the applicant can follow the applicable industry standards and manufacturer's recommendations for the specific cable application in the performance of the insulation resistance and Hi-Pot tests.

4.3.4.2 Air Oven Tests

Air oven tests can be used to evaluate the functionality of cables for those cable tray or raceway fire barrier test specimens tested without cables. This testing method consists of exposing insulated wires and cables at rated voltage to elevated temperatures in a circulating air oven. The temperature profile for regulating the temperature in the air oven during this test is the temperature measured by the AWG 8 bare copper conductor during the fire exposure of those cable tray or raceway test specimens that were tested without cables.

The test method described by UL Subject 1724, "Outline of Investigation for Fire Tests for Electrical Circuit Protective Systems," Issue Number 2, August 1991, Appendix B, "Qualification Test for Circuit Integrity of Insulated Electrical Wires and Cables in Electrical Circuit Protection Systems," is acceptable, with the following modifications.

(a) During the air oven test the cables are to be energized at rated voltage. The cables are to be monitored for conductor-to-conductor faults in multi-conductor cables and conductor-to-ground faults in all conductors.

(b) The cables being evaluated should be subjected to the

	Regulatory Position 4.3.4.2, "Cable Insulation Tests." **(c)** The impact force test, which simulates the force of impact imposed on the raceway by the solid stream test, described in UL 1724, Appendix B, paragraph B3.16, is not required to be performed. **4.3.4.4 Cable Thermal Exposure Threshold** The following analysis, which is based on determining whether a specific insulation material will maintain electrical integrity and operability within a raceway fire barrier system during and after an external fire exposure, is an acceptable method for evaluating cable functionality. In order to determine cable functionality, it is necessary to consider the operating cable temperatures within the fire barrier system at the onset of the fire exposure and the thermal exposure threshold (TET) temperature of the cable. For example, if the TET of a specific thermoplastic cable insulation (Brand X) is 149°C [300°F] and the normal operating temperature within the fire barrier system is 66°C [150°F], the maximum temperature rise within the fire barrier system should not exceed 83°C [150°F] during exposure to an external fire of a duration equal to the required fire resistance rating of the barrier. For this example, the TET limit for Brand X cable is 83°C [150°F] above the cable operating temperatures within the fire barrier system at the onset of the external fire exposure. The cable TET limits in conjunction with a post-test visual cable inspection and the Hi-Pot test described above should readily demonstrate the functionality of the cable circuit during and after a fire. The normal cable operating temperature can be determined by loading cable specimens installed within a thermal barrier system in the test configuration with rated voltage and current. The TET temperature limits for most cable insulation may be obtained from the manufacturer's published data, which is given as the short-circuit rating limit. With the known TET and normal operating temperature for each thermal barrier system configuration, the maximum temperature rise limit within a fire barrier system may then be determined. The guidance in Regulatory Position 4.3.4 is based on Appendix R to 10 CFR Part 50, APCSB 9.5-1, ASB 9.5-1, CMEB 9.5-1, GL 86-10, and Supplement 1 to GL 86-10. **4.3.5 Cable Qualification** Electric cable construction should, as a minimum, pass the flame test in IEEE Standard 383 or IEEE Standard 1202. (This does not imply that cables passing either test

	will not require additional fire protection.) For cable installations in operating plants and plants under construction prior to July 1, 1976, that do not meet the IEEE 383 flame test requirements, the cables should be covered with an approved flame retardant coating and properly derated. Non-qualified cable that is not covered with an approved flame retardant coating should be protected with an automatic fire suppression system.