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# REGULATORY GUIDE

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## FIRE PROTECTION GUIDELINES FOR NUCLEAR POWER PLANTS

FOR COMMENT

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## A. INTRODUCTION

General Design Criterion 3, "Fire Protection" of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires that structures, systems, and components important to safety be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Noncombustible and heat-resistant materials are required to be used wherever practical throughout the unit, particularly in locations such as the containment and control room. Criterion 3 also requires that fire detection and suppression systems of appropriate capacity and capability be provided and designed to minimize the adverse effect of fires on structures, systems, and components important to safety and that firefighting systems be designed to ensure that their failure, rupture, or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components.

This guide presents guidelines acceptable to the NRC staff for implementing this criterion in the development of a fire protection program for nuclear power plants. The purpose of the fire protection program is to ensure the capability to shut down the reactor and maintain it in a safe shutdown condition and to minimize radioactive releases to the environment in the event of a fire. If designs or methods different from the guidelines presented herein are used, they must provide fire protection comparable to that recommended in the guidelines. Suitable bases and justification should be provided for alternative approaches to establish acceptable implementation of General Design Criterion 3.

This guide addresses fire protection only for safety-related systems and equipment in nuclear power plants. It does not give guidance on separation criteria for redundant cable systems. Such guidance is included in Regulatory Guide 1.75, "Physical Independence of Electrical Systems." Economic and property loss considerations will probably dictate additional requirements for the fire protection program.

## B. DISCUSSION

The fire protection program for a nuclear power plant consists of design features, personnel, equipment, and procedures. Management participation in the program should begin with early design concepts and plant layout work and continue through plant operation. A qualified staff should be responsible for engineering and design of fire protection systems for nuclear power plants. This staff should also be responsible for fire prevention activities, maintenance of fire protection systems, training, and manual firefighting activities. The equipment portion of the fire protection program comprises all equipment that provides fire detection, annunciation, control, containment, suppression, and extinguishment. It is the combination of all these that provides the needed defense-in-depth protection of the public health and safety.

There have been 32 fires in operating U.S. nuclear power plants through December 1975. Of these, the fire on March 22, 1975, at Browns Ferry nuclear plant was the most severe. With approximately 250 operating reactor years of experience, one may infer a frequency on the order of one fire per ten reactor years. Thus, on the average, a nuclear power plant may experience one or more fires of varying severity during its operating life. WASH-1400, "Reactor Safety Study - An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," dated October 1975, concluded that the Browns Ferry fire did not affect the validity of the overall risk assessment. In any event, cost-effective fire protection measures should be instituted to significantly decrease the frequency and severity of fires.

A document entitled "The International Guidelines for the Fire Protection of Nuclear Power Plants," (IGL) 1974 Edition, 2nd Reprint, published on behalf of the National Nuclear Risks Insurance Pools and Association, provides a step-by-step approach to assessing the fire risk in a nuclear power plant and describes protective measures to be taken as a part of the fire protection of these plants. It provides useful guidance in this important area. The Nuclear Energy Liability and Property Insurance Association (NELPIA) has prepared a document entitled "Specifications for Fire Protection of New Plants" which gives general conditions and valuable criteria. A special review group organized by NRC under Dr. Stephen H. Hanauer, Technical Advisor to the Executive Director for Operations, to study the Browns Ferry fire issued a report, NUREG-0050, "Recommendations Related to Browns Ferry Fire," in February 1976, which contains recommendations applicable to all nuclear power plants. This guide uses the applicable information contained in these documents.

For the user's convenience, some of the terms related to fire protection are presented below with their definitions as used in this guide:

Approved - signifies that devices or assemblies have been tested and accepted for a specific purpose or application by a nationally recognized testing laboratory.

Automatic - self-acting, operating by its own mechanism when actuated by some impersonal influence such as a change in current, pressure, temperature, or mechanical configuration.

Combustible Sources - any material that will burn or sustain the combustion process whether or not it exhibits flame under exposure fire conditions that can exist at their point of application.

Concealed - if space containing combustible material is inaccessible to the extinguishing agent, the combustibles are considered to be concealed.

Design Basis Fires - fires that cause the most damage or the most severe exposure to the area or systems being considered. They are fires that may develop in local areas assuming no manual, automatic, or other firefighting action has been initiated, the fire has passed flashover (i.e., the temperature at which auto-ignition of other combustibles in the area will occur), and the fire has reached its peak burning rate.

Electrical Conduit - rigid or flexible tubing, usually either steel or aluminium, in which electrical cables are run.

Enclosed - surrounded by a case that will prevent a person from accidentally contacting live electrical parts. Can also apply to flammable liquids that are contained or encased in fire-resistive materials or buildings.

Fire Area - that portion of a building or plant that is separated from other areas by boundary fire barriers (walls, floors, or roofs) with any openings or penetrations protected with seals or closures having a fire resistance rating equal to that of the barrier.

Fire Barrier - those components of construction (walls, floors, or roofs) that are rated by approving laboratories in hours of resistance to fire and are used to prevent the spread of fire.

Fire Break - a feature of construction that prevents fire propagation along the length of cables or prevents spreading of fire to nearby combustibles within a given fire area or fire zone.

Fire Brigade - the team of plant personnel assigned to firefighting and who are trained in the fighting of fires by an approved training program.

Fire Detectors - a device designed to automatically detect the presence of fire and initiate an alarm system (see the National Fire Protection Association Standard NFPA 72E, "Automatic Fire Detectors"). Some typical fire detectors are classified as follows:

Heat Detector - a device that detects abnormally high temperature or rate-of-temperature rise.

Smoke Detector - a device that detects the visible or invisible particles of combustion.

Flame Detector - a device that detects the infrared, ultraviolet, or visible radiation produced by a fire.

Products of Combustion Detector - a detector whose actuation mechanism depends upon pyrolysis or combustion products.

Fire Protection Program - the components, procedures, and personnel utilized in carrying out all activities of fire protection. It includes such things as fire prevention, detection, annunciation, control, confinement, suppression, extinguishment, administrative procedures, fire brigade organization, inspection and maintenance, training, quality assurance, and testing.

Fire Rating - 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. (See NFPA 251.)

Fire Suppression - capability for control and extinguishing of fires (firefighting). Manual fire suppression activities include the use of hoses or portable extinguishers. Automatic fire suppression includes the use of fixed systems such as water sprinklers, Halon, or carbon dioxide.

Fire Zones - subdivisions of fire areas in which the fire suppression systems are designed to combat particular types of fires. The concept of fire zone aids in defining to the firefighter the fire parameters and the actions that would be necessary.

Noncombustible - materials, no part of which will ignite and burn when subjected to fire.

Raceway - any channel that is designed expressly for holding wires, cables, or bus bars and is used solely for this purpose.

Restricted Area - any area to which access is controlled by the licensee for purposes of protecting individuals from exposure to radiation and radioactive materials.

Safety-Related Systems and Components - systems and components required to shut down the reactor, mitigate the consequences of postulated accidents, or maintain the reactor in a safe shutdown condition.

Sprinkler System - a system of overhead piping and components from the first supply valve to the point where water discharges from the system to the fire area. The system is usually activated by heat or smoke from a fire. The system sometimes includes a controlling and/or a sectionalizing valve that is activated by a fire detection system and a device for actuating an alarm when the system is in operation. Sprinkler systems may be classified as follows:

Wet Pipe - a system employing automatic closed-head (fusible link operated) sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by a fire.

Dry Pipe - a system employing automatic closed-head sprinklers attached to a piping system containing air or nitrogen under pressure, the release of which, as from the opening of a sprinkler, permits the water pressure to open a valve known as a dry-pipe valve. The water then flows into the piping system and out the open sprinklers.

Preaction System - a system employing automatic closed-head sprinklers attached to a piping system containing air that may or may not be under pressure, with a fire detection system installed in the same areas as the sprinklers. Actuation of the fire detection system, as by a fire, opens a valve that permits water to flow into the sprinkler piping system and to be discharged from any sprinklers that have been opened by the fire.

Deluge System - a system employing open-head sprinklers and/or nozzles attached to a piping system connected to a water supply through a valve that is opened by the operation of a fire detection system installed in the areas where the sprinklers or nozzles are located. When this valve opens, water flows into the piping system and discharges from all sprinklers or nozzles attached thereto.

Standpipe and Hose Systems - a fixed piping system connected to a water supply to provide effective fire hose streams in the shortest possible time to specific areas inside the building.

The Browns Ferry fire and subsequent events have shown potential inadequacies in fire protection. Some of the major conclusions that emerged from the Browns Ferry fire investigations warrant emphasis and are discussed below.

1. Defense in Depth

Nuclear power plants use the concept of defense in depth to achieve the required high degree of safety by using echelons of safety systems. This concept is also applicable to fire safety in nuclear power plants. With respect to the fire protection program, the defense-in-depth principle is aimed at achieving an adequate balance in:

a. Preventing fires from starting;

b. Detecting fires quickly, suppressing those fires that occur, putting them out quickly, and limiting their damage; and

c. Designing plant safety systems so that a fire that starts in spite of the fire prevention program and burns for a considerable time in spite of fire protection activities will not prevent essential plant safety functions from being performed.

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

The primary objective of the fire protection program is to minimize both the probability and consequences of postulated fires. In spite of steps taken to reduce the probability of fire in the design of the plant, it is expected that fires will occur. Therefore, means should be provided to detect, control, and extinguish fires. This can be done by providing fixed fire detection and suppression systems of appropriate capability and adequate capacity in areas where the potential fire damage may jeopardize safe plant shutdown. Backup manual firefighting capability should be provided throughout the plant to limit the extent of a fire by providing portable equipment consisting of hoses, nozzles, portable extinguishers, and air breathing equipment for use by properly trained firefighting personnel.

A nuclear power plant must maintain its capability to combat a fire under any operating condition with fuel on site. A single failure in the fire protection system or direct support systems should not impair both primary and backup plant fire protection capability. For example, to avoid such a consequence, the pumping portion of fire protection water supply systems should be redundant and independent, including associated power supplies and controls. Also, failure or inadvertent operation of the fire suppression system should not result in failure of safety-related systems or components.

Postulated fires or fire protection system failures need not be considered concurrent with other plant accidents or the most severe natural phenomena, e.g., fire and a LOCA or fire and the Safe Shutdown Earthquake (SSE). However, in the event of the SSE, the fire protection system should be capable of delivering water from manual hose stations located within hose reach of areas containing equipment required for safe shutdown. 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. Thus at least manual hose and portable fire protection capability must be provided for all postulated design basis events requiring plant shutdown. The fire protection systems should, however, because of the higher probability of occurrence, retain their original design capability for (1) natural phenomena of less severity and greater frequency (approximately once in 10 years) such as tornadoes, hurricanes, floods, ice storms, or small-intensity earthquakes that are characteristic of the site geographic region and (2) for potential man-created site-related events such as oil barge collisions and aircraft crashes that have a reasonable probability of occurring at a specific plant site. The effects of lightning strikes should be included in the overall plant fire protection system.

Fire protection starts with design and must be carried through in all phases of construction and operation. Furthermore, quality assurance (QA) programs are needed to identify and rectify errors in design, construction, and operation and are an essential part of defense in depth. This guide is intended to implement the philosophy of defense-in-depth protection against the hazards of fire and its associated effects on safety-related equipment.

2. Use of Water on Electrical Fires

Experience with major electrical fires shows that water should be used if initial attempts to put out a cable fire with other agents are not immediately successful. Since prompt extinguishing of the fire is paramount to reactor safety, damage would be reduced by discreet application of water from automatic sprinklers rather than manual application with fire hoses. The widespread opinion and practice that emphasize the reasons for not using water as contrasted to those for its prompt and proper use are a concern. Firefighting procedures and fire training should provide the techniques, equipment, and skills for the use of water in fighting electrical fires in nuclear plants, particularly in areas containing a high concentration of electric cables with plastic insulation.

This is not to say that water systems should be installed everywhere. Equipment that may be damaged by water should be shielded or relocated away from the fire hazard and the water. Drains should be provided to remove any water used for fire suppression and extinguishment.

3. Establishment and Use of Fire Areas

The concept of separate fire areas for each division of safety equipment that requires redundancy will facilitate the installation of automatic water extinguishing systems since it will reduce the possibility of water damaging redundant safety-related equipment.

Fire areas should be established based on the amount of combustible material present and considering suitably chosen design basis fires so that adequate protection can be provided for safety-related systems and equipment. Design basis fires are those fires that result in the most damage or most severe exposure to the area or systems being considered.

Within each area, special attention should be given to limiting the amount of combustible material and to providing effective barriers and fire-resistive coatings to reduce the spread of a fire in these areas. A design basis fire should be assumed, and provisions should be made to limit the consequence of such a fire by providing fire barriers with suitable separation between redundant systems and components that are provided to carry out required safety functions. This separation is enhanced if the plant is divided into suitable fire areas since redundant safety equipment can then be placed in separate fire areas.

Particular design attention should be given to the use of separate isolated fire areas for redundant cables to avoid loss of redundant safety-related cables.

Provisions should also be made to limit the consequences of a fire by suitable design of the ventilation systems so that the spread of the products of combustion to other areas of the plant is prevented. Means should be provided to ventilate, exhaust, or isolate the area as required. The power supply and controls for the area ventilation system should be from outside the area, and the power and control cables should not pass through the area.

In the design, consideration should be given to providing personnel access to and escape routes from each fire area. The emergency plans for all plants should lay out access and escape routes to cover the event of a fire in critical areas of the plant.

## C. REGULATORY POSITION

### 1. Overall Requirements of the Fire Protection Program

#### a. Personnel

Responsibility for the overall fire protection program should be assigned to a designated person in the upper level of management. This person should retain ultimate responsibility even though formulation and assurance of program implementation is delegated. Such delegation of authority should be to staff personnel prepared by training and experience in fire protection and nuclear plant safety to provide a balanced approach in directing the fire protection program for the nuclear power plant.

The fire protection staff should be responsible for:

(1) Coordination of building layout and systems design with fire area requirements, including consideration of potential hazards associated with postulated design basis fires.

(2) Design and maintenance of fire detection, suppression, and extinguishing systems.

(3) Fire prevention activities.

(4) Training and manual firefighting activities of plant personnel and the fire brigade.

(NOTE: NFPA 6, "Recommendations for Organization of Industrial Fire Loss Prevention," contains useful guidance for organization and operation of the entire fire loss prevention program.)

#### b. Design Bases

The overall fire protection program should be based on evaluation of potential fire hazards throughout the plant and the effect of postulated design basis fires relative to maintaining ability to perform safe shutdown functions and minimize radioactive releases to the environment.

#### c. Backup

Total reliance should not be placed on a single automatic fire suppression system. Appropriate backup fire suppression capability should be provided.

#### d. Single-Failure Criterion

A single failure in the fire suppression system should not impair both the primary and backup fire suppression capability. For example, redundant fire water pumps with independent power supplies and controls should be provided. Postulated fires or fire protection system failures need not be considered concurrent with other plant accidents or the most severe natural phenomena. However, in the event of the most severe earthquake, i.e., the Safe Shutdown Earthquake (SSE), the fire suppression system should be capable of delivering water to manual hose stations located within hose reach of areas containing equipment required for safe plant shutdown. The fire protection systems should, however, retain their original design capability for (1) natural phenomena of less severity and greater frequency (approximately once in 10 years) such as tornadoes, hurricanes, floods, ice storms, or small-intensity earthquakes that are characteristic of the site geographic region and (2) for potential man-created site-related events such as oil barge collisions or aircraft crashes that have a reasonable probability of occurring at a specific plant site. The effects of lightning strikes should be included in the overall plant fire protection program.

e. Fire Suppression Systems

Failure or inadvertent operation of the fire suppression system should not incapacitate safety-related systems or components. Fire suppression systems that are pressurized during normal plant operation should meet the guidelines specified for moderate energy systems outside containment in Section 3.6.1 of the Standard Review Plan, NUREG-75/087.

f. Fuel Storage Areas

The fire protection program (plans. personnel, and equipment) for buildings storing new reactor fuel and for adjacent fire zones that could affect the fuel storage zone should be fully operational before fuel is received at the site.

g. Fuel Loading

The fire protection program for an entire reactor unit should be fully operational prior to initial fuel loading in that reactor unit.

h. Multiple-Reactor Sites

On multiple-reactor sites where there are operating reactors and construction of remaining units is being completed, the fire protection program should provide continuing evaluation and include additional fire barriers, fire protection capability, and administrative controls necessary to protect the operating units from construction fire hazards. The superintendent of the operating plant should have the lead responsibility for site fire protection.

i. Simultaneous Fires

Simultaneous fires in more than one reactor unit need not be considered. Because of separation requirements, a fire involving more than one reactor unit need not be considered except for facilities shared between units.

2. Administrative Procedures, Controls, and Fire Brigade

a. Administrative procedures consistent with the need for maintaining the performance of the fire protection system and personnel in nuclear power plants should be provided.

Guidance is contained in the following publications:

NFPA 4 - Organization for Fire Services
NFPA 4A - Organization of a Fire Department
NFPA 6 - Industrial Fire Loss Prevention
NFPA 7 - Management of Fire Emergencies
NFPA 8 - Management Responsibility for Effects of Fire on Operations
NFPA 27 - Private Fire Brigades

b. Effective administrative measures should be implemented to prohibit bulk storage of combustible materials inside or adjacent to safety-related buildings or systems during operation or maintenance periods. Regulatory Guide 1.39, "Housekeeping Requirements for Water-Cooled Nuclear Power Plants," provides guidance on housekeeping, including the disposal of combustible materials.

c. Normal and abnormal conditions or other anticipated operations such as modifications (e.g., breaking fire stops, impairment of fire detection and suppression systems) and refueling activities should be reviewed by appropriate levels of management and appropriate special action and procedures such as fire watches or temporary fire barriers implemented to ensure adequate fire protection and reactor safety. In particular:

(1) Work involving ignition sources such as welding and flame cutting should be done under closely controlled conditions. Procedures governing such work should be reviewed and approved by persons trained and experienced in fire protection. 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.

(2) Leak testing and similar procedures such as airflow determination should use one of the commercially available aerosol techniques. Open flames or combustion-generated smoke should not be permitted.

(3) Use of combustible material, e.g., HEPA and charcoal filters, dry ion exchange resins, or other combustible supplies, in safety-related areas should be controlled. Use of wood inside buildings containing safety-related systems or equipment should be permitted only when suitable noncombustible substitutes are not available. If wood must be used, only fire-retardant-treated wood (scaffolding, lay-down blocks) should be permitted. Such materials should be allowed into safety-related areas only when they are to be used immediately. Their possible and probable use should be considered in the fire hazard analysis to determine the adequacy of the installed fire protection systems.

d. Nuclear power plants are frequently located in remote areas at some distance from public fire departments. Also, first response fire departments are often volunteer. Public fire department response should be considered in the overall fire protection program. However, the plant should be designed to be self-sufficient with respect to firefighting activities and rely on the public response only for supplemental or backup capability.

e. The need for good organization, training, and equipping of fire brigades at nuclear power plant sites requires that effective measures be implemented to ensure proper discharge of these functions. The guidance in Regulatory Guide 1.101, "Emergency Planning for Nuclear Power Plants," should be followed as applicable.

(1) Successful firefighting requires testing and maintenance of the fire protection equipment, and the emergency lighting and communication, as well as practice as brigades for the people who must utilize the equipment. A test plan that lists the individuals and their responsibilities in connection with routine tests and inspections of the fire detection and protection systems should be developed. The test plan should contain the types, frequency, and detailed procedures for testing. 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 or temporary hose connections to water systems.

(2) Basic training is a necessary element in effective firefighting operation. In order for a fire brigade to operate effectively, it must operate as a team. All members must know what their individual duties are. They must be familiar with the layout of the plant and with equipment location and operation in order to permit effective firefighting operations during times when a particular area is filled with smoke or is insufficiently lighted. Such training can only be accomplished by conducting drills several times a year (at least quarterly) so that all members of the fire brigade have had the opportunity to train as a team testing itself in the major areas of the plant. The drills should include the simulated use of equipment in each area and should be preplanned and postcritiqued to establish the training objective of the drills and determine how well these objectives have been met. These drills should periodically (at least annually) include local fire department participation where possible. Such drills also permit supervising personnel to evaluate the effectiveness of communications within the fire brigade and with the on-scene fire team leader, the reactor operator in the control room, and the offsite command post.

(3) To have proper coverage during all phases of operation, members of each shift crew should be trained in fire protection. Training of the plant fire brigade should be coordinated with the local fire department so that responsibilities and duties are delineated in advance. This coordination should be part of the training course and implemented into the training of the local fire department staff. Local fire departments should be educated in the operational precautions when fighting fires on nuclear power plant sites. Local fire departments should be made aware of the need for radioactive protection of personnel and the special hazards associated with a nuclear power plant site.

(4) NFPA 27, "Private Fire Brigade," should be followed in organization, training, and fire drills. This standard also is applicable for the inspection and maintenance of firefighting equipment. Among the standards referenced in this document, the following should be utilized: NFPA 194, "Standards for Screw Threads and Gaskets for Fire Hose Couplings," NFPA 196, "Standard for Fire Hose," NFPA 197, "Training Standard on Initial Fire Attacks," and NFPA 601, "Recommended

Manual of Instructions and Duties for the Plant Watchman on Guard." NFPA booklets and pamphlets listed on page 27-11 of Volume 8, 1971-72, are also applicable for good training references. In addition, courses in fire prevention and fire suppression that are recognized and/or sponsored by the fire protection industry should be utilized.

3. Quality Assurance Program

Quality assurance (QA) programs of applicants and contractors should be developed and implemented to ensure that the requirements for design, procurement, installation, and testing and administrative controls for the fire protection program for safety-related areas as defined in this guide are satisfied. The program should be under the management control of the QA organization. The QA program criteria that apply to the fire protection program should include the following:

a. Design Control and Procurement Document Control

Measures should be established to ensure that all design-related guidelines of the regulatory position of this guide are included in design and procurement documents and that deviations therefrom are controlled.

b. 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.

c. Control of Purchased Material, Equipment, and Services

Measures should be established to ensure that purchased material, equipment, and services conform to the procurement documents.

d. Inspection

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

e. Test and Test Control

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

f. Inspection, Test, and Operating Status

Measures should be established to provide for the identification of items that have satisfactorily passed required tests and inspections.

g. Nonconforming Items

Measures should be established to control items that do not conform to specified requirements to prevent inadvertent use or installation.

h. Corrective Action

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

i. Records

Records should be prepared and maintained to furnish evidence that the criteria enumerated above are being met for activities affecting the fire protection program.

j. Audits

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

4. General Plant Guidelines

a. Building Design

(1) Plant layouts should be arranged to:

(a) Isolate safety-related systems from unacceptable fire hazards and

(b) Separate redundant safety-related systems from each other so that both are not subject to damage from a single fire hazard.

(2) In order to accomplish a.(1) above, safety-related systems and fire hazards should be identified throughout the plant. Therefore, a detailed fire hazard analysis should be made during initial plant design.

(3) For multiple-reactor sites, cable spreading rooms should not be shared between reactors. Each cable spreading room should be separated from other areas of the plant by barriers (walls and floors) having a minimum fire resistance of three hours. Cabling for redundant safety divisions should be separated by walls having three-hour fire barriers.

(4) Interior wall and structural components, thermal insulation materials, radiation shielding materials, and soundproofing should be noncombustible. Interior finishes should be noncombustible or listed by a nationally recognized testing laboratory such as Factory Mutual or Underwriters Laboratory, Inc., for flame spread, smoke, and fuel contribution of 25 or less in its use configuration (ASTM E-84 Test, "Surface Burning Characteristics of Building Materials").

(5) Metal deck roof construction should be noncombustible (see the building materials directory of the Underwriters Laboratory, Inc.) or listed as Class I by Factory Mutual System Approval Guide.

(6) Suspended ceilings and their supports should be of noncombustible construction. Concealed spaces should be devoid of combustibles.

(7) High-voltage/high-amperage transformers installed inside buildings containing safety-related systems should be of the dry type or insulated and cooled with noncombustible liquid.

(8) Buildings containing safety-related systems should be protected from exposure or spill fires involving oil-filled transformers by:

° Locating such transformers at least 50 feet distant or

° Ensuring that such building walls within 50 feet of oil-filled transformers are without openings and have a fire resistance rating of at least three hours.

(9) Floor drains sized to remove expected firefighting waterflow should be provided in those areas where fixed water fire suppression systems are installed. Drains should also be provided in other areas where hand hose lines may be used if such firefighting water could cause unacceptable damage to equipment in the area. Equipment should be installed on pedestals, or curbs should be provided, as required, to contain water and direct it to floor drains. (See NFPA 92, "Waterproofing and Draining of Floors.") Drains in areas containing combustible liquids should have provisions for preventing the spread of the fire throughout the drain system. Water drainage from areas that may contain radioactivity should be sampled and analyzed before discharge to the environment.

(10) Floors, walls, and ceilings enclosing separate fire areas should have a minimum fire rating of three hours. Penetrations in these fire barriers, including conduits and piping, should be sealed or closed to provide a fire resistance rating at least equal to that of the barrier itself. Door openings should be protected with equivalent rated doors, frames, and hardware that have been tested and approved by a nationally recognized laboratory. Such doors should be normally closed and locked or alarmed with alarm and annunciation in the control room. Penetrations for ventilation systems should be protected by a standard "fire door damper" where required. (See NFPA 80, "Fire Doors and Windows.")

b. Control of Combustibles

(1) Safety-related systems 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:

(a) Emergency diesel generator fuel oil day tanks.

(b) Turbine-generator oil and hydraulic control fluid systems.

(c) Reactor coolant pump lube oil system.

(2) Bulk gas storage (either compressed or cryogenic) should not be permitted inside structures housing safety-related equipment. 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 safety-related systems or equipment. (See NFPA 50A, "Gaseous Hydrogen Systems.")

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. Use of compressed gases (especially flammable and fuel gases) inside buildings should be controlled. (See NFPA 6, "Industrial Fire Loss Prevention.")

(3) The use of plastic materials should be minimized. In particular, 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 dense smoke that obscures visibility and can plug air filters, especially charcoal and HEPA. The halogenated plastics also release free chlorine and hydrogen chloride, which are toxic to humans and corrosive to equipment.

(4) Storage of flammable liquids should, as a minimum, comply with the requirements of NFPA 30, "Flammable and Combustible Liquids Code."

c. <u>Electrical Cable Construction, Cable Trays, and Cable Penetrations</u>

(1) Only noncombustible materials should be used for cable tray construction.

(2) See Regulatory Position C.6.c. for fire protection guidelines for cable spreading rooms.

(3) Automatic water sprinkler systems should be provided for cable trays outside the cable spreading room. Cables should be designed to allow wetting down with deluge water without electrical faulting. Manual hose stations and portable hand extinguishers should be provided as backup. Safety-related equipment in the vicinity of such cable trays that does not itself require water fire protection but is subject to unacceptable damage from sprinkler water discharge should be protected from sprinkler system operation or malfunction.

(4) Cable and cable tray penetration of fire barriers (vertical and horizontal) should be sealed to give protection at least equivalent to that provided by the fire barrier. The design of fire barriers for horizontal and vertical cable trays should, as a minimum, meet the requirements of ASTM E-119, "Fire Test of Building Construction and Materials," including the hose stream test.

(5) Fire breaks should be installed every 10 feet along horizontal and vertical cable routings to prevent the propagation of a fire. Flame- or fire-retardant coatings may be used as a fire break for grouped electrical cables to limit spread of fire in cable routings. (Possible cable derating owing to use of such coating materials must be considered during design.)

(6) Electric cable constructions should as a minimum pass the current IEEE No. 383 flame test. (This does not imply that cables passing this test will not require additional fire protection.)

(7) To the extent practical, cable construction that does not give off corrosive gases while burning should be used.

(8) Cable trays, raceways, conduit, trenches, or culverts should be used only for cables. Miscellaneous storage should not be permitted nor should piping for flammable or combustible liquids or gases be installed in these areas.

(9) The design of cable tunnels, culverts, and spreading rooms should provide for automatic or manual smoke venting as required to facilitate manual firefighting capability.

(10) Cables in the control room should be kept to the minimum necessary for operation of the control room. All cables entering the control room should terminate there. Cables should not be installed in floor trenches or culverts in the control room.

d. Ventilation

(1) The products of combustion that need to be removed from a specific fire area should be evaluated to determine how they will be controlled. Smoke and corrosive gases should generally be automatically discharged directly outside to a safe location. Smoke and gases containing radioactive materials should be monitored in the fire area to determine if release to the environment is within the permissible limits of the plant Technical Specifications.

(2) Any ventilation system designed to exhaust smoke or corrosive gases should be evaluated to ensure that inadvertent operation or single failures will not violate the controlled areas of the plant design. This requirement includes containment functions for protection of the public and maintaining habitability for operations personnel.

(3) The power supply and controls for mechanical ventilation systems should be run outside the fire area served by the system.

(4) Fire suppression systems should be installed to protect charcoal filters.

(5) The fresh-air supply intakes to areas containing safety-related equipment or systems should be located remote from the exhaust air outlets and smoke vents of other fire areas to minimize the possibility of contaminating the intake air with the products of combustion.

(6) Stairwells should be designed to minimize smoke infiltration during a fire. Staircases should serve as escape routes and access routes for firefighting. Fire exit routes should be clearly marked. Stairwells, elevators, and chutes should be enclosed in masonry towers with a minimum fire rating of three hours and automatic fire doors at least equal to the enclosure construction at each opening into the building. Elevators should not be used during fire emergencies.

(7) Smoke and heat vents may be useful in specific areas such as cable spreading rooms, diesel fuel oil storage areas, and switchgear rooms. When natural-convection ventilation is used, a minimum ratio of 1 square foot of vent area per 200 square feet of floor area should be provided. If forced-convection ventilation is used, 300 cfm should be provided for every 200 square feet of floor area. See NFPA 204 for additional guidance on smoke control.

(8) 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. Control room personnel may be furnished breathing air by a manifold system piped from a storage reservoir if practical. Service or operating life should be a minimum of one-half hour for the self-contained units.

At least two extra air bottles should be located on site for each self-contained breathing unit. In addition, an onsite 6-hour supply of reserve air should be provided and arranged to permit quick and complete replenishment of exhausted supply air bottles as they are returned. If compressors are used as a source of breathing air, only units approved for breathing air should be used. Special care must be taken to locate the compressor in areas free of dust and contaminants.

(9) Where total flooding gas extinguishing systems are used, area intake and exhaust ventilation dampers should close upon initiation of gas flow to maintain necessary gas concentration. (See NFPA 12, "Carbon Dioxide Systems," and NFPA 12A, "Halon 1301 Systems.")

e. Lighting and Communication

Lighting and two-way voice communication are vital to safe shutdown and emergency response in the event of fire. Suitable fixed and portable emergency lighting and communication devices should be provided to satisfy the following requirements:

(1) Fixed emergency lighting should consist of sealed beam units with individual 8-hour minimum battery power supplies.

(2) Suitable sealed-beam battery-powered portable hand lights should be provided for emergency use.

(3) Fixed emergency communication should use voice-powered headsets at preselected stations.

(4) Fixed repeaters installed to permit use of portable radio communication units should be protected from exposure fire damage.

5. <u>Fire Detection and Suppression</u>

a. <u>Fire Detection</u>

(1) Fire detection systems should, as a minimum, comply with NFPA 72D, "Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems."

(2) Fire detection systems should give audible and visual alarm and annunciation in the control room. Local audible alarms should also sound at the location of the fire.

(3) Fire alarms should be distinctive and unique. They should not be capable of being confused with any other plant system alarms.

(4) Fire detection and actuation systems should be connected to the plant emergency power supply.

b. <u>Fire Protection Water Supply Systems</u>

(1) An underground yard fire main loop should be installed to furnish anticipated water requirements. NFPA 24, "Standard for Outside Protection," gives necessary guidance for such installation. It references other design codes and standards developed by such organizations as the American National Standards Institute (ANSI) and the American Water Works Association (AWWA). Lined steel or cast iron pipe should be used to reduce internal tuberculation. Such tuberculation deposits in an unlined pipe over a period of years can significantly reduce waterflow through the combination of increased friction and reduced pipe diameter. Means for treating and flushing the systems should be provided. Approved visually indicating sectional control valves, such as post indicator valves, should be provided to isolate portions of the main for maintenance or repair without shutting off the entire system.

The fire main system piping should be separate from service or sanitary water system piping.

(2) A common yard fire main loop may serve multi-unit nuclear power plant sites if cross-connected between units. Sectional control valves should permit maintaining independence of the individual loop around each unit. For such installations, common water supplies may also be utilized. The water supply should be sized for the largest single expected flow. For multiple-reactor sites with widely separated plants (approaching 1 mile or more), separate yard fire main loops should be used.

(3) If pumps are required to meet system pressure or flow requirements, a sufficient number of pumps should be provided so that 100% capacity will be available with one pump inactive (e.g., three 50% pumps or two 100% pumps). The connection to the yard fire main loop from each fire pump should be widely separated, preferably located on opposite sides of the plant. Each pump should have its own driver with independent power supplies and control. At least one pump should be driven by nonelectrical means, preferably diesel engine. Pumps and drivers should be located in rooms separated from the remaining pumps and equipment by a minimum three-hour fire wall. Alarms indicating pump running, driver availability, or failure to start should be provided in the control room.

Details of the fire pump installation should, as a minimum, conform to NFPA 20, "Standard for the Installation of Centrifugal Fire Pumps."

(4) Two separate, reliable water supplies should be provided. If tanks are used, two 100% (minimum of 300,000 gallons each) system capacity tanks should be installed. They should be so interconnected that pumps can take suction from either or both. However, a leak in one tank or its piping should not cause both tanks to drain. The main plant fire water supply capacity should be capable of refilling either tank in a minimum of eight hours.

Common tanks are permitted for fire and sanitary or service water storage. When this is done, however, minimum fire water storage requirements should be dedicated by means of a vertical standpipe for other water services.

(5) The fire water supply (total capacity and flow rate) should be calculated on the basis of the largest expected flow rate for a period of two hours, but not less than 300,000 gallons. This flow rate should be based (conservatively) on 1,000 gpm for manual hose streams plus the greater of:

(a) All sprinkler heads open and flowing in the largest designed fire area or

(b) The largest open-head deluge system(s) operating.

(6) Lakes or freshwater ponds of sufficient size may qualify as sole source of water for fire protection but require at least two intakes to the pump supply. When a common water supply is permitted for fire protection and the ultimate heat sink, the following conditions should also be satisfied:

(a) The additional fire protection water requirements are designed into the total storage capacity and

(b) Failure of the fire protection system should not degrade the function of the ultimate heat sink.

(7) Outside manual hose installation should be sufficient to reach any location with an effective hose stream. To accomplish this, hydrants should be installed approximately every 250 feet on the yard main system. The lateral to each hydrant from the yard main should be controlled by a visually indicating or key-operated (curb) valve. A hose house equipped with hose and combination nozzle and other auxiliary equipment recommended in NFPA 24, "Outside Protection," should be provided as needed but at least every 1,000 feet.

Threads compatible with those used by local fire departments should be provided on all hydrants, hose couplings, and standpipe risers.

c. Water Sprinkler and Hose Standpipe Systems

(1) Each automatic sprinkler system and manual hose station standpipe should have an independent connection to the plant underground water main. Headers fed from each end are permitted inside buildings to supply multiple sprinkler and standpipe systems. When provided, such headers are considered an extension of the yard main system. The header arrangement should be such that no single failure can impair both the primary and backup fire protection systems. Each sprinkler and standpipe system should be equipped with OS&Y (outside screw and yoke) gate valve or other approved shutoff valve and waterflow alarm. Safety-related equipment that does not itself require sprinkler water fire protection but is subject to unacceptable damage if wet by sprinkler water discharge should be protected by water shields or baffles.

(2) All valves in the fire water systems should be electrically supervised. The electrical supervision signal should indicate in the control room and other appropriate command locations in the plant. (See NFPA 26, "Supervision of Valves.")

(3) Automatic sprinkler systems should, as a minimum, conform to requirements of appropriate standards such as NFPA 13, "Standard for the Installation of Sprinkler Systems," and NFPA 15, "Standard for Water Spray Fixed Systems."

(4) Interior manual hose installation should be able to reach any location with at least one effective hose stream. To accomplish this, standpipes with hose connections equipped with a maximum of 75 feet of 1-1/2-inch woven jacket-lined fire hose and suitable nozzles should be provided in all buildings, including containment, on all floors and should be spaced at not more than 100-foot intervals. Individual standpipes should be at least 4 inches in diameter for multiple hose connections and 2-1/2 inches in diameter for single hose connections. These systems should follow the requirements of NFPA 14, "Standpipe and Hose Systems," for sizing, spacing, and pipe support requirements.

Hose stations should be located outside entrances to normally unoccupied areas and inside normally occupied areas. Standpipes serving hose stations in areas housing safety-related equipment should have shutoff valves and pressure-reducing devices (if applicable) outside the area.

Provisions should be made to supply water at least to standpipes and hose connections for manual firefighting in areas within hose reach of equipment required for safe plant shutdown in the event of a Safe Shutdown Earthquake. The standpipe system serving such hose stations should be analyzed for SSE 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 at least satisfy ANSI Standard B31.1, "Power Piping." 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 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.

(5) 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 may cause unacceptable mechanical damage (for example, to delicate electronic equipment in the control room) and be unsuitable. Electrically safe nozzles should be provided at locations where electrical equipment or cabling is located.

(6) Certain fires such as those involving flammable liquids respond well to foam suppression. Consideration should be given to use of any of the available foams for such specialized protection application. These include the more common chemical and mechanical low-expansion foams, high-expansion foam, and the relatively new aqueous film-forming foam (AFFF).

d. Halon Suppression Systems

The use of Halon fire extinguishing agents should, as a minimum, comply with the requirements of NFPA 12A and 12B, "Halogenated Fire Extinguishing Agent Systems - Halon 1301 and Halon 1211." Only UL or FM approved agents should be used.

In addition to the guidelines of NFPA 12A and 12B, preventive maintenance and testing of the systems, including check-weighing of the Halon cylinders, should be done at least quarterly.

Particular consideration should also be given to:

(1) Minimum required Halon concentration and soak time.

(2) Toxicity of Halon.

(3) Toxicity and corrosive characteristics of thermal decomposition products of Halon.

e. Carbon Dioxide Suppression Systems

The use of carbon dioxide extinguishing systems should, as a minimum, comply with the requirements of NFPA 12, "Carbon Dioxide Extinguishing Systems."

Particular consideration should also be given to:

(1) Minimum required $CO_2$ concentration and soak time;

(2) Toxicity of $CO_2$;

(3) Possibility of secondary thermal shock (cooling) damage;

(4) Offsetting requirements for venting during $CO_2$ injection to prevent overpressurization versus sealing to prevent loss of agent;

(5) Design requirements from overpressurization; and

(6) Possibility and probability of $CO_2$ systems being out of service because of personnel safety consideration. $CO_2$ systems are disarmed whenever people are present in an area so protected. Areas entered frequently (even though duration time for any visit is short) have often been found with $CO_2$ systems shut off.

f. Portable Extinguishers

Fire extinguishers should be provided in accordance with guidelines of NFPA 10, "Portable Fire Extinguishers, Installation," and 10A, "Portable Fire Extinguishers, Maintenance and Use." Dry chemical extinguishers should be installed with due consideration given to cleanup problems after use and possible adverse effects on equipment installed in the area.

6. Guidelines for Specific Plant Areas

a. Primary and Secondary Containment

(1) Normal Operation - Fire protection requirements for the primary and secondary containment areas should be provided on the basis of specific identified hazards. For example:

- Lubricating oil or hydraulic fluid system for the primary coolant pumps
- Cable tray arrangements and cable penetrations
- Charcoal filters

Because of the general inaccessibility of these areas during normal plant operation, protection should be provided by automatic fixed systems. Automatic sprinklers should be installed for those hazards identified as requiring fixed suppression.

Operation of the fire protection systems should not compromise the integrity of the containment or other safety-related systems. Fire protection activities in the containment areas should function in conjunction with total containment requirements such as control of contaminated liquid and gaseous release and ventilation.

Fire detection systems should alarm and annunciate in the control room. The type of detection used and the location of the detectors should be most suitable to the particular type of fire that could be expected from the identified hazard. A primary containment general area fire detection capability should be provided as backup for the above-described hazard detection. To accomplish this, suitable smoke detectors (e.g., visual obscuration, light scattering, and particle counting) should be installed in the air recirculation system ahead of any filters.

Automatic fire suppression capability need not be provided in the primary containment atmospheres that are inerted during normal operation. However, special fire protection requirements during refueling and maintenance operations should be satisfied as provided below.

(2) Refueling and Maintenance - Refueling and maintenance operations in containment may introduce additional hazards such as contamination control materials, decontamination supplies, wood planking, temporary wiring, welding, and flame cutting (with portable compressed fuel gas supply). Possible fires would not necessarily be in the vicinity of fixed detection and suppression systems.

Management procedures and controls necessary to ensure adequate fire protection are discussed in Section C.1. In addition, manual firefighting capability should be permanently installed in containment. Standpipes with hose stations and portable fire extinguishers should be installed at strategic locations throughout containment for any required manual firefighting operations.

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.

b. Control Room

The control room is essential to safe reactor operation. It must be protected against disabling fire damage and should be separated from other areas of the plant by floors, walls, and roof having minimum fire resistance ratings of three hours.

Control room cabinets and consoles are subject to damage from two distinct fire hazards:

(1) Fire originating within a cabinet or console and

(2) Exposure fires involving combustibles in the general room area.

Manual firefighting capability should be provided for both hazards. Hose stations and portable water and Halon extinguishers should be located in the control room to eliminate the need for operators to leave the control room. An additional hose piping shutoff valve and pressure-reducing device should be installed outside the control room.

Nozzles that are compatible with the hazards and equipment in the control room should be provided for the manual hose station. The nozzles chosen should satisfy actual firefighting needs, satisfy electrical safety, and minimize physical damage to electrical equipment from hose stream impingement.

Fire detection in the control room, cabinets, and consoles should be provided by smoke and heat detectors in each fire area. Alarm and annunciation should be provided in the control room. Fire alarms in other parts of the plant should also be alarmed and annunciated in the control room.

Breathing apparatus for control room operators should be readily available. Control room floors, ceilings, supporting structures, and walls, including penetrations and doors, should be designed to a minimum fire rating of three hours. All penetration seals should be airtight.

The control room ventilation intake should be provided with smoke detection capability to automatically alarm locally and isolate the control room ventilation system to protect operators by preventing smoke from entering the control room. Manually operated venting of the control room should be available so that operators have the option of venting for visibility.

Cables should not be located in concealed floors and ceiling spaces. All cables that enter the control room should terminate in the control room. That is, no cabling should be simply routed through the control room from one area to another.

Safety-related equipment should be mounted on pedestals, or the control room should have curbs and 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.

c. <u>Cable Spreading Room</u>

The primary fire suppression in the cable spreading room should be an automatic water system such as closed-head sprinklers, open-head deluge, or open directional spray nozzles. Deluge and open spray systems should have provisions for manual operation at a remote station; however, there should be provisions to preclude inadvertent operation. Location of sprinkler heads or spray nozzles should consider cable tray sizing and arrangements to ensure adequate water coverage. Cables should be designed to allow wetting down with deluge water without electrical faulting.

Open-head deluge and open directional spray systems should be zoned so that a single failure will not deprive the entire area of automatic fire suppression capability.

The use of foam is acceptable, provided it is of a type capable of being delivered by a sprinkler or deluge system, such as an aqueous film-forming foam (AFFF).

An automatic water suppression system with manual hoses and portable extinguisher backup is acceptable, provided:

(1) At least two remote and separate entrances are provided to the room for access by fire brigade personnel and

(2) Aisle separation provided between tray stacks should be at least three feet wide and eight feet high.

Alternatively, gas systems (Halon or $CO_2$) may be used for primary fire suppression if they are backed up by an installed water spray system and hose stations and portable extinguishers immediately outside the room and if the access requirements stated above are met.

Electric cable construction should, as a minimum, pass the flame test in IEEE Std 383, "IEEE Standard Type Test of Class IE Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations."

Drains to remove firefighting water should be provided with adequate seals when gas extinguishing systems are also installed.

Redundant safety-related cable divisions should be separated by walls with a three-hour fire rating.

For multiple-reactor unit sites, cable spreading rooms should not be shared between reactors. Each cable spreading room of each unit should have divisional cable separation as stated above and be separated from the other and the rest of the plant by a wall with a minimum fire rating of three hours. (See NFPA 251, "Fire Tests, Building Construction and Materials," or ASTM E-119, "Fire Test of Building Construction and Materials," for fire test resistance rating.)

The ventilation system to the cable spreading room should be designed to isolate the area upon actuation of any gas extinguishing system in the area. In addition, smoke venting of the cable spreading room may be desirable. Such smoke venting systems should be controlled automatically by the fire detection or suppression system as appropriate. Capability for remote manual control should also be provided.

d. Plant Computer Room

Computer rooms should be separated from other areas of the plant by barriers having a minimum fire resistance rating of three hours. Automatic fire detection should be provided to alarm and annunciate in the control room and alarm locally. Manual hose stations and portable water and Halon fire extinguishers should be provided.

e. Switchgear Rooms

Switchgear rooms should be separated from the remainder of the plant by barriers with a minimum fire rating of three hours. Redundant switchgear safety divisions should be separated by three-hour fire rated barriers. Automatic fire detectors should alarm and annunciate in the control room and alarm locally. All cables that enter the switchgear room should terminate there. These rooms should not be used for any other purpose. Fire hose stations and portable fire extinguishers should be readily available.

Equipment should be located on pedestals or curbs, and drains should be provided to direct water away from safety-related equipment. (See NFPA 92M, "Waterproofing and Draining of Floors.") Remote manually actuated ventilation should be provided for venting smoke when manual fire suppression effort is needed.

f. Remote Safety-Related Panels

The general area housing remote safety-related panels should be provided with automatic fire detectors that alarm locally and alarm and annunciate in the control room. Combustible materials should be controlled and limited to those required for operation. Portable extinguishers and manual hose stations should be provided.

g. Station Battery Rooms

Battery rooms should be protected against fire explosions. Battery rooms should be separated from each other and other areas of the plant by barriers having a minimum fire rating of three hours inclusive of all penetrations and openings. (See NFPA 69, "Standard on Explosion Prevention Systems.") Battery rooms should be provided with hydrogen concentration detectors that alarm and annunciate in the control room and alarm locally. The detector alarm setpoint should be no greater than 2 vol-% hydrogen concentration. Ventilation systems in the battery rooms should be capable of maintaining the hydrogen concentration well below the detector alarm setpoint. Standpipe and hose and portable extinguishers should be provided.

h. Turbine Lubrication and Control Oil Storage and Use Areas

A blank fire wall having a minimum resistance rating of three hours should separate all areas containing safety-related systems and equipment from the turbine oil systems.

i. Diesel Generator Areas

Diesel generators should be separated from each other and other areas of the plant by fire barriers having a minimum fire resistance rating of three hours.

Automatic fire suppression such as AFFF, foam, or sprinklers should be installed to combat any diesel generator or lubricating oil fires. Automatic fire detection should be provided to alarm and annunciate in the control room and alarm locally. Drainage for firefighting water and means for local manual venting of smoke should be provided.

Day tanks with total capacity up to 1100 gallons are permitted in the diesel generator area under the following conditions:

(1) The day tank is located in a separate enclosure with a minimum fire resistance rating of three hours, including doors or penetrations. These enclosures should be capable of containing the entire contents of the day tanks. The enclosure should be ventilated to avoid accumulation of oil fumes.

(2) The enclosure should be protected by an automatic fire suppression system such as AFFF or sprinklers.

j. Diesel Fuel Oil Storage Areas

Diesel fuel oil tanks with a capacity greater than 1100 gallons should not be located inside the buildings containing safety-related equipment. They should be located at least 50 feet from any building containing safety-related equipment or, if located within 50 feet, they should be housed in a separate building with construction having a minimum fire resistance rating of three hours. Buried tanks are considered as meeting the three-hour fire resistance requirements. See NFPA 30, "Flammable and Combustible Liquids Code," for additional guidance.

When located in a separate building, the tank should be protected by an automatic fire suppression system such as AFFF or sprinklers.

Tanks should not be located directly above or below safety-related systems or equipment regardless of the fire rating of separating floors or ceilings.

k. Safety-Related Pumps

Pump houses and rooms housing safety-related pumps or other safety-related equipment should be separated from other areas of the plant by fire barriers having at least three-hour ratings. These rooms should be protected by automatic sprinkler protection unless a fire hazards analysis can demonstrate that a fire will not endanger other safety-related equipment required for safe plant shutdown. Early warning fire detection should be installed with alarm and annunciation locally and in the control room. Local hose stations and portable extinguishers should also be provided.

Equipment pedestals or curbs and drains should be provided to remove and direct water away from safety-related equipment.

Provisions should be made for manual control of the ventilation system to facilitate smoke removal if required for manual firefighting operation.

l. New Fuel Area

Hand portable extinguishers should be located within this area. Also, local hose stations should be located outside but within hose reach of this area. Automatic fire detection should alarm and annunciate in the control room and alarm locally. Combustibles should be limited to a minimum in the new fuel area. The storage area should be provided with a drainage system to preclude accumulation of water.

The storage configuration of new fuel should always be so maintained as to preclude criticality for any water density that might occur during fire water application.

m. Spent Fuel Pool Area

Protection for the spent fuel pool area should be provided by local hose stations and portable extinguishers. Automatic fire detection should be provided to alarm and annunciate in the control room and to alarm locally.

n. Radwaste Building

The radwaste building should be separated from other areas of the plant by fire barriers having at least three-hour ratings. Automatic sprinklers should be used in all areas where combustible materials are located. Automatic fire detection should be provided to annunciate and alarm in the control room and alarm locally. During a fire, the ventilation systems in these areas should be capable of being isolated. Water should drain to liquid radwaste building sumps.

o. Decontamination Areas

The decontamination areas should be separated from other areas of the plant by fire barriers having at least three-hour ratings. These areas should be protected by automatic sprinklers. Automatic fire detection should be provided to annunciate and alarm in the control room and alarm locally. The ventilation system should be capable of being isolated. Local hose stations and hand portable extinguishers should be provided as backup to the sprinkler system.

p. Safety-Related Water Tanks

Storage tanks that supply water for safe shutdown should be protected from the effects of fire. Local hose stations and portable extinguishers should be provided. Portable extinguishers should be located in nearby hose houses. Combustible materials should not be stored next to outdoor tanks. A minimum of 50 feet of separation should be provided between outdoor tanks and combustible materials where feasible.

q. Records Storage Areas

Records storage areas should be protected with automatic preaction sprinkler systems. Early warning fire detectors should be provided to alarm and annunciate in the control room and to alarm locally. Local hose stations and portable extinguishers should serve as backup. (See NFPA 232AM, "Manual for Fire Protection for Archives and Records Centers," Regulatory Guide 1.88, "Collection, Storage, and Maintenance of Nuclear Power Quality Assurance Records," and ANSI N45.2.9, "Requirements for Collection, Storage, and Maintenance of Quality Assurance Records for Nuclear Power Plants.")

r. Cooling Towers

Cooling towers should be of noncombustible construction or so located that a fire will not adversely affect any safety-related systems or equipment. Cooling towers should be of noncombustible construction when the basins are used for the ultimate heat sink or for the fire protection water supply.

s. Miscellaneous Areas

Miscellaneous areas such as shops, warehouses, and auxiliary boiler rooms should be so located that a fire or effects of a fire, including smoke, will not adversely affect any safety-related systems or equipment. Fuel oil tanks for auxiliary boilers should be buried or provided with dikes to contain the entire tank contents.

7. Special Protection Guidelines

a. Welding and Cutting Acetylene-Oxygen Fuel Gas Systems

This equipment is used in various areas throughout the plant. Storage locations should be chosen to permit fire protection by automatic sprinkler systems. Local hose stations and portable equipment should be provided as backup. The requirements of NFPA 51 and 51B are applicable to these hazards. A permit system should be required to utilize this equipment. (Also see C.2 herein.)

b. Storage Areas for Dry Ion Exchange Resins

Dry ion exchange resins should not be stored near essential safety-related systems. Dry unused resins should be protected by automatic wet pipe sprinkler installations. Detection by smoke and heat detectors should alarm and annunciate in the control room and alarm locally. Local hose stations and portable extinguishers should provide backup for these areas. Storage areas of dry resin should have curbs and drains. (See NFPA 92M, "Waterproofing and Draining of Floors.")

c. Hazardous Chemicals

Hazardous chemicals should be stored and protected in accordance with the recommendations of NFPA 49, "Hazardous Chemicals Data." Chemical storage areas should be well ventilated and protected against flooding conditions since some chemicals may react with water to produce ignition.

d. Materials Containing Radioactivity

Materials that collect and contain radioactivity such as spent ion exchange resins, charcoal filters, and HEPA filters should be stored in closed metal tanks or containers that are located in areas free from ignition sources or combustibles. These materials should be protected from exposure to fires in adjacent areas as well. Consideration should be given to requirements for removal of isotopic decay heat from entrained radioactive materials.

## D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used in the evaluation of submittals in connection with construction permit applications docketed after February 28, 1977.

If an applicant wishes to use this regulatory guide in developing submittals for applications docketed on or before February 28, 1977, the pertinent portions of the application will be evaluated on the basis of this guide.

## REFERENCES

National Fire Protection Association Codes and Standards


NFPA 4, "Organization of Fire Services."

NFPA 4A, "Fire Department Organization."

NFPA 6, "Industrial Fire Loss Prevention."

NFPA 7, "Fire Emergencies Mangement."

NFPA 8, "Effects of Fire on Operations, Management Responsiblity."

NFPA 10, "Portable Fire Extinguishers, Installation."

NFPA 10A, "Portable Fire Extinguishers, Maintenance and Use."

NFPA 11, "Foam Extinguishing Systems."

NFPA 12, "Carbon Dioxide Systems."

NFPA 12A, "Halon 1301 Systems."

NFPA 12B, "Halon 1211 Systems."

NFPA 14, "Standpipe and Hose Systems."

NFPA 15, "Water Spray Fixed Systems."

NFPA 20, "Centrifugal Fire Pumps."

NFPA 24, "Outside Protection."

NFPA 26, "Supervision of Valves."

NFPA 27, "Private Fire Brigade."

NFPA 30, "Flammable Combustible Liquids Code."

NFPA 49, "Hazardous Chemicals Data."

NFPA 50A, "Gaseous Hydrogen Systems."

NFPA 69, "Explosion Prevention System."

NFPA 72D, "Proprietary Signaling Systems."

NFPA 80, "Fire Doors and Windows."

NFPA 92M, "Waterproofing and Draining of Floors,"

NFPA 194, "Fire Hose Connections."

NFPA 196, "Fire Hose."

NFPA 197, "Initial Fire Attack, Training, Standard On."

NFPA 204, "Smoke and Heat Venting Guide."

NFPA 232 AM, "Archives and Record Centers."

NFPA 251, "Fire Tests, Building Construction and Materials."

NFPA 601, "Guard Service in Fire Loss Prevention."

U.S. Nuclear Regulatory Commission Documents

NUREG-0050, "Recommendations Related to Browns Ferry Fire," Report by Special Review Group, published February 1976.

WASH-1400 (NUREG-75/014), "Reactor Safety Study - An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," published October 1975.

Standard Review Plan 9.5.1, "Fire Protection System."

Standard Review Plan 3.6.1, "Plant Design for Protection Against Postulated Piping Failures in Fluid Systems Outside Containment."

Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," General Design Criterion 3, "Fire Protection."

Regulatory Guide 1.39, "Housekeeping Requirements for Water-Cooled Nuclear Power Plants."

Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," Revision 2, Section 9.5.1.

Regulatory Guide 1.75, "Physical Independence of Electrical Systems."

Regulatory Guide 1.88, "Collection, Storage, and Maintenance of Nuclear Power Plant Quality Assurance Records."

Regulatory Guide 1.101, "Emergency Planning for Nuclear Power Plants."

Other Documents

ANSI Standard B31.1, "Power Piping."

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