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FIRE PROTECTION GUIDELINES FOR NUCLEAR POWER PLANTS

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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. It implements the philosophy of defense-in-depth protection against the hazards of fire and its associated effects on safety-related equipment. If designs or methods different from the guidelines recommended herein are used, they must provide equivalent fire protection. Suitable bases and justification should be provided for alternative approaches to establish acceptable implementation of General Design Criterion 3.

This guide addresses fire protection programs for safety-related systems and equipment and for other plant areas containing fire hazards that could adversely affect safety-related systems. It does not give guidance for protecting the life safety of the site personnel or for protection against economic or property loss. This guide supplements Regulatory Guide 1.75, "Physical Independence of Electrical Systems," in determining the fire protection for redundant cable systems.

B. DISCUSSION

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. Although 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, the staff concluded that cost-effective fire protection measures should be instituted to significantly decrease the frequency and severity of fires and consequently initiated the development of this guide. In this development, the staff made use of many national standards and other publications related to fire protection. The documents discussed below were particularly useful.

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) and the Mutual Atomic Energy Reinsurance Pool (MAERP) have 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.

The fire protection program for a nuclear power plant presented in this guide consists of design features, personnel, equipment, and procedures that provide the defense-in-depth protection of the public health and safety. The purpose of the program is to prevent significant fires, 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 significant

fire. To meet this objective, it is essential that management participation in the program begin with early design concepts and plant layout work and continue through plant operation and that a qualified staff be responsible for engineering and design of fire protection systems that provide fire detection, annunciation, confinement, and suppression for the plant. The staff should also be responsible for fire prevention activities, maintenance of fire protection systems, training, and manual firefighting activities. It is the combination of all these that provides the needed defense-in-depth protection of the public health and safety.

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, fires are expected to occur. Therefore, means are needed to detect and suppress fires with particular emphasis on providing passive and active fire protection of appropriate capability and adequate capacity for the systems necessary to achieve and maintain safe plant shutdown with or without offsite power. For other safety-related systems, the fire protection should ensure that a fire will not cause the loss of function of such systems, even though loss of redundancy within a system may occur as a result of the fire. Generally, in plant areas where the potential fire damage may jeopardize safe plant shutdown, the primary means of fire protection should consist of fire barriers and fixed automatic fire detection and suppression systems. Also, a backup manual firefighting capability should be provided throughout the plant to limit the extent of fire damage. Portable equipment consisting of hoses, nozzles, portable extinguishers, complete personnel protective equipment, and air breathing equipment should be provided for use by properly trained firefighting personnel. Access for effective manual application of fire extinguishing agents to combustibles should be provided. The adequacy of fire protection for any particular plant safety system or area should be determined by analysis of the effects of the postulated fire relative to maintaining the ability to safely shut down the plant and minimize radioactive releases to the environment in the event of a fire.

Fire protection starts with design and must be carried through all phases of construction and operation. A quality assurance (QA) program is needed to identify and rectify errors in design, construction, and operation and is an essential part of defense in depth.

2. Use of Water on Electrical Cable Fires

Experience with major electrical cable fires shows that water will promptly extinguish such fires. Since prompt extinguishing of the fire is vital to reactor safety, fire and water damage to safety systems is reduced by the more efficient application of water from fixed systems spraying directly on the fire rather than by manual application with fire hoses. Appropriate firefighting procedures and fire training should provide the techniques, equipment, and skills 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.

This is not to say that fixed 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 to ensure that water accumulation does not incapacitate safety-related equipment.

3. Establishment and Use of Fire Areas

Separate fire areas for each division of safety-related systems will reduce the possibility of fire-related damage to redundant safety-related equipment. Fire areas should be established to separate redundant safety divisions and isolate safety-related systems from fire hazards in non-safety-related areas. Particular design attention to the use of separate isolated fire areas for redundant cables will help to avoid loss of redundant safety-related cables. Separate fire areas should also be employed to limit the spread of fires between components that are major fire hazards within a safety division. Where redundant systems cannot be separated by fire barriers, as in containment and the control room, it is necessary to employ other measures to prevent a fire from causing the loss of function of safety-related systems.

Within fire areas containing components of a safety-related system, special attention should be given to detecting and suppressing fires that may adversely affect the system. Measures that may be taken to reduce the effects of a postulated fire in a given fire area include limiting the amount of combustible materials, installing fire-resistant construction, providing fire stops or fire-retardant coating in cable trays, installing fire detection systems and fixed fire suppression systems, or providing other protection suitable to the installation. The fire hazard analysis will be the mechanism to determine that fire areas have been properly selected.

Suitable design of the ventilation systems can limit the consequences of a fire by preventing the spread of the products of combustion to other fire areas. It is important that means be provided to ventilate, exhaust, or isolate the fire area as required and that consideration be given to the consequences of failure of ventilation systems due to fire causing loss of control for ventilating, exhausting, or isolating a given fire area. The capability to ventilate, exhaust, or isolate is particularly important to ensure the habitability of rooms or spaces that must be attended in an emergency. In the design, provision should be made for personnel access to and escape routes from each fire area.

4. Definitions

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 - 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 Material - material that does not meet the definition of noncombustible.

Control Room Complex - the zone served by the control room emergency ventilation system (see Standard Review Plan 6.4, "Habitability Systems").

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

Fire Barrier - 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.

Fire Stop - 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 equipped for and trained in the fighting of fires.

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

Heat Detector - a device that detects a predetermined (fixed) temperature or rate of temperature rise.

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

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

Line-Type Detector - a device in which detection is continuous along a path, e.g., fixed-temperature, heat-sensitive cable and rate-of-rise pneumatic tubing detectors.

Fire Protection Program - the integrated effort involving components, procedures, and personnel utilized in carrying out all activities of fire protection. It includes system and facility design, fire prevention, fire detection, annunciation, confinement, suppression, administrative controls, 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 - control and extinguishing of fires (firefighting). Manual fire suppression is the use of hoses, portable extinguishers, or manually actuated fixed systems by plant personnel. Automatic fire suppression is the use of automatically actuated fixed systems such as water, Halon, or carbon dioxide systems.

Fire Zones - the subdivisions of fire areas in which the fire suppression systems are designed to combat particular types of fires.

Noncombustible Material

a. material, no part of which will ignite and burn when subjected to fire.

b. material having a structural base of noncombustible material, as defined in a., with a surfacing not over 1/16 inch thick that has a flame spread rating not higher than 50 when measured using ASTM E-84 Test, "Surface Burning Characteristics of Building Materials."

Raceway - refer to Regulatory Guide 1.75.

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.

Secondary Containment - a structure that completely encloses primary containment, used for controlling containment leakage.

Sprinkler System - a network of piping connected to a reliable water supply that will distribute the water throughout the area protected and will discharge the water through sprinklers in sufficient quantity either to extinguish the fire entirely or to prevent its spread. The system, usually activated by heat, includes a controlling valve and a device for actuating an alarm when the system is in operation. The following categories of sprinkler systems are defined in NFPA 13, "Standard for the Installation of Sprinkler Systems":

- Wet-Pipe System
- Dry-Pipe System
- Preaction System
- Deluge System
- Combined Dry-Pipe and Preaction System
- On-Off System

Standpipe and Hose Systems - a fixed piping system with hose outlets, hose, and nozzles connected to a reliable water supply to provide effective fire hose streams to specific areas inside the building.

Water Spray System - a network of piping similar to a sprinkler system except that it utilizes open-head spray nozzles. NFPA 15, "Water Spray Fixed Systems," provides guidance on these systems.

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 who has management control over the organizations involved in fire protection activities. This person should retain ultimate responsibility even though formulation and assurance of program implementation is delegated. Such delegation of authority should be 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 balanced approach in directing the fire protection program for the nuclear power plant.

The staff should be responsible for:

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

(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.

(5) Pre-fire planning.

On sites where there is an operating reactor and construction or modification of other units is underway, the superintendent of the operating plant should have the lead responsibility for site fire protection.

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

b. Fire Hazard Analysis

The overall fire protection program should allow the plant to maintain the ability to perform safe shutdown functions and minimize radioactive releases to the environment in the event of a fire. A major element of this program should be the evaluation of potential fire hazards throughout the plant and the effect of postulated fires on safety-related plant areas.

Fire initiation should be postulated at the location that will produce the most severe fire, assuming an ignition source is present at that point. Fire development should consider the potential for involvement of other combustibles, both fixed and transient, in the fire area. Where automatic suppression systems are installed, the effects of the postulated fire should be evaluated with and without actuation of the automatic suppression system.

(1) A detailed fire hazard analysis should be made during initial plant design to reflect the proposed construction arrangement, materials, and facilities. This analysis should be revised periodically as design and construction progress and before and during major plant modifications.

(2) The fire hazard analysis should be a systematic study of (a) all elements of the fire protection program being proposed to ensure that the plant design has included adequate identification and evaluation of potential fire hazards and (b) the effect of postulated fires relative to maintaining the ability to perform safe shutdown functions and minimizing radioactive releases to the environment.

(3) Experienced judgement is necessary to identify fire hazards and the consequences of a postulated fire starting at any point in the plant. Evaluation of the consequences of the postulated fire on nuclear safety should be performed by persons thoroughly trained and experienced in reactor safety. The person conducting the analysis of fire hazards should be thoroughly trained and experienced in the principles of industrial fire prevention and control and in fire phenomena from fire initiation, through its development, to propagation into adjoining spaces. The fire hazard analysis should be conducted by or under the direct supervision of an engineer who is qualified for Member grade in the Society of Fire Protection Engineers.

(4) The fire hazard analysis should separately identify hazards and provide appropriate protection in locations where safety-related losses can occur as a result of:

(a) Concentrations of combustible contents, including transient fire loads due to combustibles expected to be used in normal operations such as refueling, maintenance, and modifications;

(b) Continuity of combustible contents, furnishings, building materials, or combinations thereof in configurations conducive to fire spread;

(c) Exposure fire, heat, smoke, or water exposure, including those that may necessitate evacuation from areas that are required to be attended for safe shutdown;

(d) Fire in control rooms or other locations having critical safety-related functions;

(e) Lack of adequate access or smoke removal facilities that impede fire extinguishment in safety-related areas;

(f) Lack of explosion-prevention measures;

(g) Loss of electric power or control circuits; and

(h) Inadvertent operation of fire suppression systems.

(5) The fire hazard analysis should verify that the fire protection program guidelines of the regulatory position of this guide have been met. To that end, the report on the analysis should list applicable elements of the program, with explanatory statements as needed to identify location, type of system, and design criteria. The report should identify any deviations from the regulatory position and should present alternatives for staff review. Justification for deviations from the regulatory position should show that an equivalent level of protection will be achieved. Deletion of a protective feature without compensating alternative protective measures generally will not be acceptable, unless it is clearly demonstrated that the protective measure is not needed because of the design and arrangement of the particular plant.

c. Fire Suppression System Design Basis

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

(2) A single active failure or a crack in a moderate-energy line (pipe) in the fire suppression system should not impair both the primary and backup fire suppression capability. For example, neither the failure of a fire pump, its power supply, or controls nor a crack in a moderate-energy line in the fire suppression system should result in loss of function of both sprinkler and hose standpipe systems in an area protected by such primary and backup systems.

(3) As a minimum, 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 following the Safe Shutdown Earthquake (SSE). In areas of high seismic activity, the staff will consider on a case-by-case basis the need to design the fire detection and suppression systems to be functional following the SSE.

(4) The fire protection systems should retain their original design capability for (a) natural phenomena of less severity and greater frequency than the most severe natural phenomena (approximately once in 10 years) such as tornadoes, hurricanes, floods, ice storms, or small-intensity earthquakes that are characteristic of the geographic region and (b) 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.

(5) The consequences of inadvertent operation of or a crack in a moderate energy line in the fire suppression system should meet the guidelines specified for moderate-energy systems outside containment in Section 3.6.1 of the Standard Review Plan, NUREG-75/087.

d. Simultaneous Events

(1) Fires need not be postulated to be concurrent with non-fire-related failures in safety systems, other plant accidents, or the most severe natural phenomena.

(2) On multiple-reactor sites, unrelated fires need not be postulated to occur simultaneously in more than one reactor unit. The effects of fires involving facilities shared between units and fires due to man-created site-related events that have a reasonable probability of

occurring and affecting more than one reactor unit (such as an aircraft crash) should be considered.

e. Implementation of Fire Protection Programs

(1) The fire protection program (plans, personnel, and equipment) for buildings storing new reactor fuel and for adjacent fire areas that could affect the fuel storage area should be fully operational before fuel is received at the site. Such adjacent areas include those whose flames, hot gases, and fire-generated toxic and corrosive products may jeopardize safety and surveillance of the stored fuel.

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

(3) On reactor sites where there is an operating reactor and construction or modification of other units is under way, the fire protection program should provide for continuing evaluation of fire hazards. Additional fire barriers, fire protection capability, and administrative controls should be provided as necessary to protect the operating unit from construction fire hazards.

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
NFPA 802 - Recommended Fire Protection Practice for Nuclear Reactors.

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 provides guidance on housekeeping, including the disposal of combustible materials.

c. Normal and abnormal conditions or other anticipated operations such as modifications (e.g., breaching fire barriers or fire stops, impairment of fire detection and suppression systems) and transient fire load conditions such as those associated with refueling activities should be reviewed by appropriate levels of management and the fire protection staff. Appropriate special action and procedures such as fire watches or temporary fire barriers should be 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 monitored conditions that are controlled by a permit system. 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 trained in firefighting techniques and plant emergency procedures should directly monitor the work and function as a fire watch. In instances where such operations may produce flame, sparks, or molten metal through walls or penetrations, care should be taken to inspect both rooms or areas (see NFPA-51B, "Cutting and Welding Processes").

(2) 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) 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 and the effects on safety-related equipment.

(4) Disarming of fire detection or fire suppression systems should be controlled by a permit system. Fire watches should be established in areas where systems are so disarmed.

d. The plant should be designed to be self-sufficient with respect to firefighting activities to protect safety-related plant areas. Public fire department response should be provided for in the overall fire protection program for supplemental and 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 and classroom instruction 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 provide for local fire department participation periodically (at least annually). 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, the plant physical security organization, and any other 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 should be included in the training of the local fire department staff. The plant fire brigade should not include any of the plant physical security personnel required to be available to fulfill the response requirements of paragraph 73.55(h)(2) of 10 CFR Part 73, "Physical Protection of Plants and Materials." Local fire departments should be provided training in operational precautions when fighting fires on nuclear power plant sites and should be made aware of the need for radiological protection of personnel and the special hazards associated with a nuclear power plant site.

(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, NFPA 197, "Training Standard on Initial Fire Attacks," should be utilized as applicable. NFPA booklets and pamphlets listed in NFPA 27 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 utilized.

3. Quality Assurance Program

The quality assurance (QA) programs of applicants and contractors should ensure that the guidelines for design, procurement, installation, and testing and the administrative controls for the fire protection systems for safety-related areas are satisfied. The QA program should be under the management control of the QA organization. This control consists of (1) formulating a fire protection QA program that incorporates suitable requirements and is acceptable to the management responsible for fire protection or verifying that the program incorporates suitable requirements and is acceptable to the management responsible for fire protection and (2) verifying the effectiveness of the QA program for fire protection through review, surveillance, and audits. Performance of other QA program functions for meeting the fire protection program requirements may be performed by personnel outside of the QA organization. The QA program for fire protection

should be part of the overall plant QA program. It should satisfy the specific criteria listed below.

a. Design and Procurement Document Control

Measures should be established to ensure that the 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) Fire barriers with a minimum fire resistance rating of three hours should be used, except as noted in other paragraphs, to:

(a) Isolate safety-related systems from any potential fires in non-safety-related areas that could affect their ability to perform their safety function;

(b) Separate redundant divisions or trains of safety-related systems from each other so that both are not subject to damage from a single fire hazard; and

(c) Separate individual units on a multiple-unit site unless the requirements of General Design Criterion 5 can be met with respect to fires.

(2) Appropriate fire barriers should be provided within a single safety division to separate components that present a fire hazard to other safety-related components or high concentrations of safety-related cables within that division.

(3) Each cable spreading room should contain only one redundant safety division. Cable spreading rooms should not be shared between reactors. Cable spreading rooms should be separated from each other and from other areas of the plant by barriers having a minimum fire resistance of three hours.

(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:

(a) Surface flamespread rating of 50 or less when tested under ASTM E-84, and

(b) Potential heat release of 3500 Btu/lb or less when tested under ASTM D-3286 or NFPA 259.[1]

Materials that are acceptable for use as interior finish without evidence of test and listing by a nationally recognized laboratory are the following:

- Plaster, acoustic plaster
- Gypsum plasterboard (gypsum wallboard)
- Any of the above, 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
- Vinyl tile, vinyl-asbestos tile, linoleum, or asphalt tile on concrete floors.

(5) Metal deck roof construction should be noncombustible, listed as "acceptable for fire" in the UL Building Materials Directory, or listed as Class I in the Factory Mutual System Approval Guide.

(6) Suspended ceilings and their supports should be of noncombustible construction. Concealed spaces should be devoid of combustibles except as noted in Regulatory Position C.6.b.

(7) Transformers installed inside fire areas containing safety-related systems should be of the dry type or insulated and cooled with noncombustible liquid. Where transformers filled with combustible fluid are located in non-safety-related areas, there should be no openings in the fire barriers separating such transformers from areas containing safety-related systems or equipment.

(8) Buildings containing safety-related systems should be protected from exposure or spill fires involving outdoor oil-filled transformers by providing oil spill confinement or drainage away from the buildings and:

Locating such transformers at least 50 feet distant from the building, 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.

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[1] The concept of using a potential heat release limit of 3500 Btu/lb is similar to the "limited combustible" concept with its like limit, as set forth in NFPA 220.

(9) Floor drains sized to remove expected firefighting waterflow without flooding safety-related equipment should be provided in those areas where fixed water fire suppression systems are installed. Floor drains should also be provided in other areas where hand hose lines may be used if such firefighting water could cause unacceptable damage to safety-related equipment in the area (see NFPA-92, "Waterproofing and Draining of Floors"). Where gas suppression systems are installed, the drains should be provided with adequate seals or the gas suppression system should be sized to compensate for the loss of the suppression agent through the drains. 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 collected, sampled, and analyzed before discharge to the environment.

(10) Floors, walls, and ceilings separating fire areas should have a minimum fire rating of three hours. Openings through fire barriers around conduit or piping should be sealed or closed to provide a fire resistance rating at least equal to that required of the barrier itself. Door openings should be protected with equivalently rated doors, frames, and hardware that have been tested and approved by a nationally recognized laboratory. Such doors should be normally closed and delay-alarmed with alarm and annunciation in the control room, locked closed, or equipped with automatic self-closing devices using magnetic hold-open devices that are activated by smoke or rate-of-rise heat detectors protecting both sides of the opening. The status of doors equipped with magnetic hold-open devices should be indicated in the control room. Fire barrier openings for ventilation systems should be protected by a "fire door damper" having a rating equivalent to that required of the barrier (see NFPA 80, "Fire Doors and Windows"). Flexible air duct coupling in ventilation and filter systems should be noncombustible.

(11) Personnel access routes and escape routes should be provided for each fire area. Stairwells outside primary containment serving as escape routes, access routes for firefighting, or access routes to areas containing equipment necessary for safe shutdown should be enclosed in masonry or concrete towers with a minimum fire rating of two hours and self-closing Class B fire doors.

(12) Fire exit routes should be clearly marked.

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, automatic fire suppression should be provided to limit the consequences of a fire.

(2) Use and storage of compressed gases (especially oxygen and flammable gases) inside buildings housing safety-related equipment should be controlled. Bulk storage of flammable gas should not be permitted inside structures housing safety-related equipment and should be sufficiently remote that a fire or explosion will not adversely affect any safety-related systems or equipment (see NFPA 6, "Industrial Fire Loss Prevention").

(3) It is recognized that halogenated compounds are used to improve the fire retardancy of cable insulation; insulating and jacketing materials should be chosen to have a high flame resistance and low smoke and offgas characteristics without degrading the required electrical and physical properties. However, plastic materials should not be used for other applications unless suitable noncombustible materials are not available.

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

c. Electrical Cable Construction, Cable Trays, and Cable Penetrations

(1) 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 to equipment. Other raceways should be made of noncombustible material.

(2) Redundant safety-related cable systems outside the cable spreading room should be separated from each other and from potential fire exposure hazards in non-safety-related areas by fire barriers with a minimum fire rating of three hours. These cable trays should be provided with continuous line-type heat detectors and should be accessible for manual firefighting. Cables should be designed to allow wetting down with fire suppression water without electrical faulting. Manual hose stations and portable hand extinguishers should be provided. Safety-related equipment in the vicinity of such cable trays that does not itself require fixed water suppression systems but is subject to unacceptable damage from water should be protected.

Safety-related cable trays of a single division that are separated from redundant divisions by a fire barrier with a minimum rating of 3 hours and are normally accessible for manual firefighting should be protected from the effects of a potential exposure fire by providing automatic water suppression in the area where such a fire could occur. Automatic area protection, where provided, should consider cable tray arrangements and possible transient combustibles to ensure adequate water coverage for areas that could present an exposure hazard to the cable system. Manual hose standpipe systems may be relied upon to provide the primary fire suppression (in lieu of automatic water suppression systems) for safety-related cable trays of a single division that are separated from redundant safety divisions by a fire barrier with a minimum rating of 3 hours and are normally accessible for manual firefighting if all of the following conditions are met:

(a) The number of equivalent[2] standard 24-inch-wide cable trays (both safety-related and non-safety-related) in a given fire area is six or less;

(b) The cabling does not provide instrumentation, control, or power to systems required to achieve and maintain cold shutdown; and

(c) Smoke detectors are provided in the area of these cable routings, and continuous line-type heat detectors are provided in the cable trays.

Safety-related cable trays that are not accessible for manual fighting should be protected by a zoned automatic water system with open-head deluge or open directional spray nozzles arranged so that adequate water coverage is provided for each cable tray. Such cable trays should also be protected from the effects of a potential exposure fire by providing automatic water suppression in the area where such a fire could occur.

In such plant areas as primary and secondary containment or other areas where it may not be possible because of other overriding design features necessary for reasons of nuclear safety to separate redundant safety-related cable systems by 3-hour-rated fire barriers, cable trays should be protected by an automatic water system with open-head deluge or open directional spray nozzles arranged so that adequate water coverage is provided for each cable tray. Such cable trays should also be protected from the effects of a potential exposure fire by providing automatic water suppression in the area where such a fire could occur. The capability to achieve and maintain safe shutdown considering the effects of a fire involving fixed and potential transient combustibles should be evaluated with and without actuation of the automatic suppression system and should be justified on a suitably defined basis.

(3) Cable and cable tray penetration of fire barriers (vertical and horizontal) should be sealed to give protection at least equivalent to that required of the fire barrier. The design of fire barrier penetrations for horizontal and vertical cable trays should be qualified by tests.[3] The penetration qualification tests should use the time-temperature exposure curve specified by ASTM E-119, "Fire Test of Building Construction and Materials." Openings inside conduit larger than 4 inches in diameter should be sealed at the fire barrier penetration; these seals should be qualified by tests as described above. Openings inside conduit 4 inches or less in diameter should be sealed at the fire barrier and should be qualified by tests as described above unless the conduit extends at least 5 feet on each side of the fire barrier and is sealed either at both ends or at the fire barrier with noncombustible material to prevent the passage of smoke and hot gases. Fire barrier penetrations that must maintain environmental isolation or pressure differentials should be qualified by test to maintain the barrier integrity under the conditions specified above.

(4) Fire stops should be installed every 20 feet along horizontal cable routings in areas that are not protected by automatic water systems. Vertical cable routings should have fire stops installed at each floor/ceiling level. Between levels or in vertical cable chases, fire stops should be installed at the midheight if the vertical run is 20 feet or more but less than 30 feet or at 15-foot intervals in vertical runs of 30 feet or more unless such vertical cable routings are protected by automatic water systems directed on the cable trays. Individual fire stop designs should prevent the propagation of a fire for a minimum period of thirty minutes when tested for the largest number of cable routings and maximum cable density.

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[2] Trays exceeding 24 inches should be counted as two trays; trays exceeding 48 inches should be counted as three trays, regardless of tray fill.

[3] Penetration qualification test criteria are under development. Guidance is currently available in the form of a draft standard, "Standard for Cable Penetration Fire Stop Test Procedure," being developed by Task Force 12-40 of the IEEE Insulated Conductors Committee.

(5) Electric cable constructions should, as a minimum, pass the flame test in the current IEEE Std 383. (This does not imply that cables passing this test will not require fire protection.)

(6) Cable raceways should be used only for cables.

(7) Miscellaneous storage and piping for flammable or combustible liquids or gases should not create a potential exposure hazard to safety-related systems.

d. Ventilation

(1) The products of combustion and the means by which they will be removed from each fire area should be established during the initial stages of plant design. Consideration should be given to the installation of automatic suppression systems as a means of limiting smoke and heat generation. Smoke and corrosive gases should generally be discharged directly outside to an area that will not affect safety-related plant areas. The normal plant ventilation system may be used for this purpose if capable and available. To facilitate manual firefighting, separate smoke and heat vents should be provided in specific areas such as cable spreading rooms, diesel fuel oil storage areas, switchgear rooms, and other areas where the potential exists for heavy smoke conditions (see NFPA 204 for additional guidance on smoke control).

(2) Release of smoke and gases containing radioactive materials to the environment should be monitored in accordance with emergency plans as described in the guidelines of Regulatory Guide 1.101, "Emergency Planning for Nuclear Power Plants." Any ventilation system designed to exhaust potentially radioactive smoke or gases should be evaluated to ensure that inadvertent operation or single failures will not violate the radiologically controlled areas of the plant design. This requirement includes containment functions for protecting the public and maintaining habitability for operations personnel.

(3) Special protection for ventilation power and control cables may be required. The power supply and controls for mechanical ventilation systems should be run outside the fire area served by the system where practical.

(4) Engineered-safety-feature filters should be protected in accordance with the guidelines of Regulatory Guide 1.52. Any filter that includes combustible materials and is a potential exposure fire hazard that may affect safety-related components should be protected as determined by the fire hazard analysis.

(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.

(7) 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 rated 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; compressors should be operable assuming a loss of offsite power. Special care must be taken to locate the compressor in areas free of dust and contaminants.

(8) Where total flooding gas extinguishing systems are used, area intake and exhaust ventilation dampers should be controlled in accordance with NFPA 12, "Carbon Dioxide Systems," and NFPA 12A, "Halon 1301 Systems, to maintain the necessary gas concentration.

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 as follows:

(1) Fixed self-contained lighting consisting of fluorescent or sealed-beam units with individual 8-hour-minimum battery power supplies should be provided in areas that must be manned

for safe shutdown and for access and egress routes to and from all fire areas. Safe shutdown areas include those required to be manned if the control room must be evacuated.

(2) Suitable sealed-beam battery-powered portable hand lights should be provided for emergency use by the fire brigade and other operations personnel required to achieve safe plant shutdown.

(3) Fixed emergency communications independent of the normal plant communication system should be installed at preselected stations.

(4) 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. Preoperational and periodic testing should demonstrate that the frequencies used for portable radio communication will not affect the actuation of protective relays.

5. Fire Detection and Suppression

a. Fire Detection

(1) Area fire detection systems should be provided for all areas that contain, or present potential fire exposure to, safety-related equipment.

(2) Fire detection systems should, as a minimum, comply with the requirements of Class A systems as defined in NFPA 72D, "Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems," and Class I circuits as defined in NFPA 70, "National Electrical Code."

(3) Fire detectors should, as a minimum, be selected and installed in accordance with NFPA 72E, "Automatic Fire Detectors." Preoperational and periodic testing of pulsed line-type heat detectors should demonstrate that the frequencies used will not affect the actuation of protective relays.

(4) Fire detection systems should give audible and visual alarm and annunciation in the control room. Where zoned detection systems are used in a given fire area, local means should be provided to identify which detector zone has actuated. Local audible alarms should sound in the fire area.

(5) Fire alarms should be distinctive and unique so they will not be confused with any other plant system alarms.

(6) Primary and secondary power supplies should be provided for the fire detection system and for electrically operated control valves for automatic suppression systems. Such primary and secondary power supplies should satisfy provisions of Section 2220 of NFPA 72D. This can be accomplished by:

(a) Using normal offsite power as the primary supply with a four-hour battery supply as secondary supply; and

(b) Having capability for manual connection to the Class 1E emergency power bus within four hours of loss of offsite power. Such connection should follow the applicable guidelines in Regulatory Guides 1.6, 1.32, and 1.75.

b. Fire Protection Water Supply Systems

(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). Type of pipe and water treatment should be design considerations with tuberculation as one of the parameters. Means for inspecting 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 supply to primary and backup fire suppression systems serving areas that contain or expose safety-related equipment.

The fire main system piping should be separate from service or sanitary water system piping, except as described in Regulatory Position C.5.c.(4).

(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. 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 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:

(a) Electric-motor-driven fire pump(s) and diesel-driven fire pump(s); or

(b) Two or more Seismic Category I Class 1E electric-motor-driven fire pumps connected to redundant Class 1E emergency power buses (see Rgulatory Guides 1.6, 1.32, and 1.75).

Individual fire pump connections to the yard fire main loop should be separated with sectionalizing valves between connections. Each pump and its driver and controls should be located in a room separated from the remaining fire pumps by a fire wall with a minimum rating of 3 hours. The fuel for the diesel fire pump(s) should be separated so that it does not provide a fire source exposing safety-related equipment. Alarms indicating pump running, driver availability, failure to start, and low fire-main pressure 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 freshwater supplies should be provided. Saltwater or brackish water should not be used unless all freshwater supplies have been exhausted. 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 be isolable so that it will not cause both tanks to drain. Water supply capacity should be capable of refilling either tank in eight hours or less.

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 passive means, for example, use of a vertical standpipe for other water services.

(5) The fire water supply 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 750 gpm for manual hose streams plus the largest design demand of any sprinkler or deluge system as determined in accordance with NFPA 13 or NFPA 15. The fire water supply should be capable of delivering this design demand over the longest route of the water supply system.

(6) Freshwater lakes or ponds of sufficient size may qualify as sole source of water for fire protection but require at least two intakes to the pump supply. One hundred percent capacity should be available following the loss of any one intake. 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 provide an effective hose stream to any onsite location where fixed or transient combustibles could jeopardize safety-related equipment. To accomplish this, hydrants should be installed approximately every 250 feet on the yard main system. 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. 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.

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) Sprinkler systems and manual hose station standpipes should have connections to the plant underground water main so that no single active failure or crack in a moderate-energy line can 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 ANSI B31.1, "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. When provided, such headers are considered an extension of the yard main system. Hose standpipe and automatic water suppression systems serving a single fire area should have independent connections to the yard main 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) Control and sectionalizing valves in the fire water systems should be electrically supervised or administratively controlled. The electrical supervision signal should indicate in the control room. All valves in the fire protection system should be periodically checked to verify position (see NFPA 26, "Supervision of Valves").

(3) Fixed water extinguishing 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 that contains, or could present a fire exposure hazard to, safety-related equipment with at least one effective hose stream. To accomplish this, standpipes with hose connections equipped with a maximum of 100 feet of 1-1/2-inch woven-jacket, lined fire hose and suitable nozzles should be provided in all buildings on all floors. 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 as dictated by the fire hazard analysis to facilitate access and use for firefighting operations. Alternative hose stations should be provided for an area if the fire hazard could block access to a single hose station serving that area.

Provisions should be made to supply water at least to 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 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, as a minimum, satisfy ANSI 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 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.")

(6) Certain fires, such as those involving flammable liquids, respond well to foam suppression. Consideration should be given to use of mechanical low-expansion foam systems, high-expansion foam generators, or aqueous film-forming foam (AFFF) systems, including the AFFF deluge system. These systems should comply with the requirements of NFPA 11, NFPA 11A, and NFPA 11B as applicable.

d. Halon Suppression Systems

Halon fire extinguishing systems 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-listed or FM-approved agents should be used. 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 C.2.c. are provided.

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, distribution, soak time, and ventilation control;

(2) Toxicity of Halon;

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

(4) Location and selection of the activating detectors.

e. Carbon Dioxide Suppression Systems

Carbon dioxide extinguishing systems should, as a minimum, comply with the requirements of NFPA 12, "Carbon Dioxide Extinguishing Systems." Where automatic carbon dioxide systems are used, they should be equipped with a predischarge alarm system and a discharge delay to permit personnel egress. 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 C.2.c. are provided.

Particular consideration should also be given to:

(1) Minimum required CO_2 concentration, distribution, soak time, and ventilation control;

(2) Anoxia and toxicity of CO_2;

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

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

(5) Location and selection of the activating detectors.

f. Portable Extinguishers

Fire extinguishers should be provided in areas that contain, or could present a fire exposure hazard to, safety-related equipment in accordance with guidelines of NFPA 10, "Portable Fire Extinguishers, Installation, Maintenance, and Use." Dry chemical extinguishers should be installed with due consideration given to possible adverse effects on safety-related 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 for hazards identified by the fire hazard analysis. Examples of such hazards include lubricating oil or hydraulic fluid system for the primary coolant pumps, cable tray arrangements and cable penetrations, and charcoal filters. Because of the general inaccessibility of primary containment during normal plant operation, protection should be provided by automatic fixed systems. The effects of postulated fires within the primary containment should be evaluated to ensure that the integrity of the primary coolant system and the containment is not jeopardized assuming no action is taken to fight the fire.

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 ventilation and control of contaminated liquid and gaseous release.

In primary containment, fire detection systems should be provided for each fire hazard. The type of detection used and the location of the detectors should be the most suitable for the particular type of fire hazard identified by the fire hazard analysis.

A general area fire detection capability should be provided in the primary containment as backup for the above-described hazard detection. To accomplish this, suitable smoke or heat detectors compatible with the radiation environment should be installed.

For secondary containment areas, cable fire hazards that could affect safety should be protected as described in Regulatory Position C.4.c(2). The type of detection system for other fire hazards identified by the fire hazard analysis should be the most suitable for the particular type of fire hazard.

(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-gas fuel 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 for transient fire loads are discussed in Regulatory Position C.1.

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. The containment penetrations of the standpipe system should meet the isolation requirements of General Design Criterion 56 and should be Seismic Category I and Quality Group B.

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.

b. Control Room Complex

The control room complex (including galleys, office spaces, etc.) should 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. Peripheral rooms in the control room complex should have automatic fire suppression and should be separated from the control room by noncombustible construction with a fire resistance rating of one hour. 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 carbon dioxide flooding system is used for fire suppression, these dampers should be strong enough to support the pressure rise accompanying carbon dioxide discharge and seal tightly against infiltration of carbon dioxide into the control room.

Manual firefighting capability should be provided for:

(1) Fire originating within a cabinet, console, or connecting cables; and

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

Portable Class A and Class C fire extinguishers should be located in the control room. A hose station should be installed immediately 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.

Smoke detectors should be provided in the control room, cabinets, and consoles. If redundant safe-shutdown equipment is located in the same control room cabinet or console, additional fire protection measures should be provided. Alarm and local indication should be provided in the control room.

Breathing apparatus for control room operators should be readily available.

The outside air intake(s) for the control room ventilation system should be provided with smoke detection capability to alarm in the control room to enable manual isolation of the control room ventilation system and thus prevent smoke from entering the control room.

Venting of smoke produced by fire in the control room by means of the normal ventilation system is acceptable; however, provision should be made to permit isolation of the recirculating portion of the normal ventilation system. Manually operated venting of the control room should be available to the operators.

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. Cables in the control room should be kept to the minimum necessary for plant operation.

Cables in underfloor and ceiling spaces should meet the separation criteria given in Regulatory Guide 1.75. Air-handling functions should be ducted separately from cable runs in such spaces; i.e., if cables are routed in underfloor or ceiling spaces, these spaces should not be used as air plenums for ventilation of the control room. Fully enclosed electrical raceways in such underfloor and ceiling spaces, if over one square foot in cross-sectional area, should have automatic fire suppression inside. Area automatic fire suppression should be provided for underfloor and ceiling spaces if used for cable runs unless all cable is run in 4-inch or smaller steel conduit or the cables are in fully enclosed raceways internally protected by automatic fire suppression.

c. Cable Spreading Room

The primary fire suppression in the cable spreading room should be an automatic water system such as closed-head sprinklers, open-head deluge system, or open directional water spray system. 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 arrangements and possible transient combustibles to ensure adequate water coverage for areas that could present exposure hazards to the cable system. Cables should be designed to allow wetting down with water supplied by the fire suppression system without electrical faulting.

Open-head deluge and open directional spray systems should be zoned.

The use of foam is acceptable.

Automatic gas systems (Halon or CO_2) may be used for primary fire suppression if they are backed up by a fixed water spray system.

Cable spreading rooms should have:

(1) At least two remote and separate entrances for access by fire brigade personnel;

(2) An aisle separation between tray stacks at least 3 feet wide and 8 feet high;

(3) Hose stations and portable extinguishers installed immediately outside the room;

(4) Area smoke detection; and

(5) Continuous line-type heat detectors for cable trays inside the cable spreading room.

Drains to remove firefighting water should be provided. When gas systems are installed, drains should have adequate seals or the gas extinguishing systems should be sized to compensate for losses through the drains.

A separate cable spreading room should be provided for each redundant division. Cable spreading rooms should not be shared between reactors. Each cable spreading room should be separated from the others and from other areas of the plant by barriers with a minimum fire rating of three hours.

The ventilation system to each cable spreading room should be designed to isolate the area upon actuation of any gas extinguishing system in the area. Separate manually actuated smoke venting that is operable from outside the room should be provided for the cable spreading room.

d. Plant Computer Rooms

Computer rooms for computers performing safety-related functions that are not part of the control room complex should be separated from other areas of the plant by barriers having a minimum fire resistance rating of three hours and should be protected by automatic detection and

fixed automatic suppression. Computers that are part of the control room complex but not in the control room should be separated and protected as described in Regulatory Position C.6.b. Computer cabinets located in the control room should be protected as other control room equipment and cable runs therein. Non-safety-related computers outside the control room complex should be separated from safety-related areas by fire barriers with a minimum rating of three hours and should be protected as needed to prevent fire and smoke damage to safety-related equipment. Manual hose stations and portable fire extinguishers should be provided in areas that contain, or could present a fire exposure hazard to, safety-related equipment.

e. Switchgear Rooms

Switchgear rooms containing safety-related equipment 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 from each other by barriers with a three-hour fire rating. Automatic fire detectors should alarm and annunciate in the control room and alarm locally. Cables entering the switchgear room that do not terminate or perform a function there should be kept at a minimum to minimize the combustible loading. These rooms should not be used for any other purpose. Fire hose stations and portable fire extinguishers should be readily available outside the area.

Equipment should be located to facilitate access for manual firefighting. Drains should be provided to prevent water accumulation from damaging 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 (see Regulatory Position C.4.d).

f. Remote Safety-Related Panels

Redundant safety-related panels remote from the control room complex should be separated from each other by barriers having a minimum fire rating of three hours. Panels providing remote hot shutdown capability should be separated from the control room complex by barriers having a minimum fire rating of three hours. 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 readily available in the general area.

g. Safety-Related Battery Rooms

Safety-related battery rooms should be protected against fires and 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. D.C. switchgear and inverters should not be located in these battery rooms. Automatic fire detection should be provided to alarm and annunciate in the control room and alarm locally. Ventilation systems in the battery rooms should be capable of maintaining the hydrogen concentration well below 2 vol-%. Loss of ventilation should be alarmed in the control room. Standpipe and hose and portable extinguishers should be readily available outside the room.

h. Turbine Building

The turbine building should be separated from adjacent structures containing safety-related equipment by a fire barrier with a minimum rating of three hours. Openings and penetrations in the fire barrier should be minimized and should not be located where the turbine oil system or generator hydrogen cooling system creates a direct fire exposure hazard to the barrier. Considering the severity of the fire hazards, defense in depth may dictate additional protection to ensure barrier integrity.

i. Diesel Generator Areas

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

Automatic fire suppression should be installed to combat any diesel generator or lubricating oil fires; such systems should be designed for operation when the diesel is running without affecting the diesel. Automatic fire detection should be provided to alarm and annunciate in the control room and alarm locally. Hose stations and portable extinguishers should be readily available outside the area. 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 and should be protected by an automatic fire suppression system, or

(2) The day tank is located inside the diesel generator room in a diked enclosure that has sufficient capacity to hold 110% of the contents of the day tank or is drained to a safe location.

j. Diesel Fuel Oil Storage Areas

Diesel fuel oil tanks with a capacity greater than 1100 gallons should not be located inside buildings containing safety-related equipment. If above-ground tanks are used, 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. Potential oil spills should be confined or directed away from buildings containing safety-related equipment. Totally buried tanks are acceptable outside or under buildings (see NFPA 30, "Flammable and Combustible Liquids Code," for additional guidance).

Above-ground tanks should be protected by an automatic fire suppression system.

k. Safety-Related Pumps

Pump houses and rooms housing redundant safety-related pump trains should be separated from each other and from other areas of the plant by fire barriers having at least three-hour ratings. These rooms should be protected by automatic fire detection and suppression unless a fire hazard analysis can demonstrate that a fire will not endanger other safety-related equipment required for safe plant shutdown. Fire detection should alarm and annunciate in the control room and alarm locally. Hose stations and portable extinguishers should be readily accessible.

Floor drains should be provided to prevent water accumulation from damaging safety-related equipment (see Regulatory Position C.4.a.(9)).

Provisions should be made for manual control of the ventilation system to facilitate smoke removal if required for manual firefighting operation (see Regulatory Position C.4.d).

l. New Fuel Area

Hand portable extinguishers should be located within this area. Also, 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 and Decontamination Areas

Fire barriers, automatic fire suppression and detection, and ventilation controls should be provided unless the fire hazard analysis can demonstrate that such protection is not necessary.

o. Safety-Related Water Tanks

Storage tanks that supply water for safe shutdown should be protected from the effects of an exposure fire. Combustible materials should not be stored next to outdoor tanks.

p. Records Storage Areas

Records storage areas should be so located and protected that a fire in these areas does not expose safety-related systems or equipment (see Regulatory Guide 1.88, "Collection, Storage, and Maintenance of Nuclear Power Quality Assurance Records").

q. Cooling Towers

Cooling towers should be of noncombustible construction or so located and protected 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.

r. Miscellaneous Areas

Miscellaneous areas such as shops, warehouses, auxiliary boiler rooms, fuel oil tanks, and flammable and combustible liquid storage tanks should be so located and protected that a fire or effects of a fire, including smoke, will not adversely affect any safety-related systems or equipment.

7. Special Protection Guidelines

a. Storage Acetylene-Oxygen Fuel Gases

Gas cylinder storage locations should not be in areas that contain or expose safety-related equipment or the fire protection systems that serve those safety-related areas. A permit system should be required to use this equipment in safety-related areas of the plant (also see Regulatory Position C.2).

b. Storage Areas for Ion Exchange Resins

Unused ion exchange resins should not be stored in areas that contain or expose safety-related equipment.

c. Hazardous Chemicals

Hazardous chemicals should not be stored in areas that contain or expose safety-related equipment.

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 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.

This guide is being issued for an extended public comment period of one year.

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NFPA 8-1974, "Effects of Fire on Operations, Management Responsiblity."

NFPA 10-1975, "Portable Fire Extinguishers, Installation, Maintenance, and Use."

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Section 9.5.1, "Fire Protection System."

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

Section 6.4, "Habitability Systems."

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Regulatory Guide 1.6, "Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems."

Regulatory Guide 1.32, "Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants."

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

Regulatory Guide 1.52, "Design, Testing, and Maintenance Criteria for Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-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."

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