U.S. NUCLEAR REGULATORY COMMISSION **April 2001**

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 1.189

(Draft was issued as DG-1097)

FIRE PROTECTION FOR OPERATING NUCLEAR POWER PLANTS

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A. INTRODUCTION

The primary objectives of fire protection programs at U.S. nuclear plants are to minimize both the probability of occurrence and the consequences of fire. To meet these objectives, the fire protection programs for operating nuclear power plants are designed to provide reasonable assurance, through defense in depth, that a fire will not prevent the performance of necessary safe shutdown functions and that radioactive releases to the environment in the event of a fire will be minimized.

The NRC's regulatory framework for nuclear plant fire protection programs is a number of regulations and supporting guidelines, including, but not limited to, General Design Criterion 3 (GDC 3), 10 CFR 50.48, Appendix R to 10 CFR Part 50, regulatory guides, generic communications (e.g., Generic Letters, Bulletins, and Information Notices), NUREG reports, the Standard Review Plan (NUREG-0800) and associated Branch Technical Positions, and industry standards. Since all the fire protection regulations promulgated by the NRC are not applicable to all plants, they have not been characterized as regulations in this guide. Licensees should refer to their plant-specific licensing bases to determine the applicability of a specific regulation to a specific plant.

Section B, Discussion, of this guide provides a brief history and discussion of the development and application of fire protection regulations and guidelines in the U.S. commercial nuclear power industry. The discussion includes summaries of the applicable regulations, the primary fire protection objectives, the varied licensing and design bases, and the primary assumptions relative to postulated fire events for nuclear power reactors.

Section C, Regulatory Position, provides staff positions and guidance relative to providing an acceptable level of fire protection for operating nuclear power plants. The positions and guidance provided are a compilation of the fire protection requirements and guidelines from the existing regulations and staff guidance. In addition, as appropriate, new guidance is provided where the existing guidance is weak or non-existent.

Section D, Implementation, describes how the NRC staff will use this guide.

This regulatory guide has been developed to provide a comprehensive fire protection guidance document and to identify the scope and depth of fire protection that the staff would consider acceptable for nuclear plants currently operating as of January 1, 2001. This guide may be used for licensee self-assessments and as the deterministic basis for future rulemaking. Risk-informed and performance-based alternatives to the guidance presented in this regulatory guide may be acceptable to the NRC staff.

The information collections contained in this regulatory guide are covered by the requirements of 10 CFR Part 50, which were approved by the Office of Management and Budget, approval number 3150-0011. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

B. DISCUSSION

BACKGROUND

During the initial implementation of the U.S. nuclear reactor program, regulatory acceptance of fire protection programs at nuclear power plants was based on the broad performance objectives of General Design Criterion 3 (GDC 3) in Appendix A to 10 CFR Part 50. Appendix A establishes the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components important to safety. GDC 3 addresses fire protection requirements and specifies, in part, that (1) structures, systems, and components important to safety must be designed and located to minimize the probability and effects of fires and explosions, (2) noncombustible and heat-resistant materials be used wherever practical, and (3) fire detection and suppression systems be provided to minimize the adverse effects of fires on structures, systems, and components important to safety. However, during this early stage of nuclear power regulation, given the lack of detailed implementation guidance for this general design criterion, the level of fire protection was generally found to be acceptable if the facility complied with local fire codes and received an acceptable rating from its fire insurance underwriter. Thus, the fire protection features installed in early U.S. nuclear power plants were very similar to those installed in conventional fossil-fuel power generation stations.

A fire at the Browns Ferry Nuclear Power Plant, Unit 1, on March 22, 1975, was a pivotal event that brought fundamental change to fire protection and its regulation in the U.S. nuclear power industry. The fire started when plant workers in the cable spreading room used an open flame to test for air leakage through a non-fire-rated (polyurethane foam) penetration seal that led to the reactor building. The fire ignited both the seal material and the electrical cables that passed through it, and burned for almost 7 hours before it was extinguished using a water hose stream. The greatest amount of fire damage actually occurred on the reactor building side of the penetration, in an area roughly 12.2 m (40 feet) by 6.1 m (20 feet). More than 1600 cables, routed in 117 conduits and 26 cable trays, were affected and, of those cables affected, 628 were important to safety. The fire damage to electrical power, control systems, and instrumentation cables impeded the functioning of both normal and standby reactor cooling systems and degraded plant monitoring capability for the operators. Given the loss of multiple safety systems, operators had to initiate emergency repairs in order to restore the systems needed to place the reactor in a safe shutdown condition.

The investigations that followed the Browns Ferry fire identified significant deficiencies, both in the design of fire protection features and in licensee procedures for responding to a fire event. The investigators concluded that the occupant safety and property protection concerns of fire insurance underwriters did not sufficiently encompass nuclear safety issues, especially in terms of the potential for fire damage to cause the failure of redundant success paths of systems and components important for safe reactor shutdown. In its report (NUREG-0050, February 1976, “Recommendations Related to Browns Ferry Fire”), the NRC Browns Ferry special review team recommended that the NRC (1) develop detailed guidance for implementing the general design criterion for fire protection and (2) conduct a detailed review of the fire protection program at each operating nuclear power plant, comparing it to the guidance developed.

In May 1976, the NRC issued Branch Technical Position (BTP) APCSB 9.5-1, which incorporated the recommendations from the Browns Ferry fire special review team and provided technical guidelines to assist licensees in preparing their fire protection programs. As part of this action, the staff requested each licensee to provide an analysis that divided the plant into distinct fire areas and demonstrated that redundant success paths of equipment required to achieve and maintain safe shutdown conditions for the reactor were adequately protected from fire damage. However, the guidelines of APCSB 9.5-1 applied only to those licensees that filed for a construction permit after July 1, 1976.

In September 1976, in an effort to establish defense-in-depth fire protection programs, without significantly affecting the design, construction, or operation of existing plants that were either already operating or well past the design stage and into construction, the NRC modified the guidelines in APCSB 9.5-1 and issued Appendix A to APCSB 9.5-1. This guidance provided acceptable alternatives in areas where strict compliance with APCSB 9.5-1 would require significant modifications. Additionally, the NRC informed each plant that the guidance in Appendix A would be used to analyze the consequences of a postulated fire within each area of the plant and requested licensees to provide results of the fire hazards analysis performed for each unit and the technical specifications for the present fire protection systems.

Early in 1977 each licensee responded with a fire protection program evaluation that included a fire hazard analysis. These analyses were reviewed by the staff using the guidelines of Appendix A to APCSB 9.5-1. The staff also conducted inspections of operating reactors to examine the relationship of structures, systems, and components important to safety with the fire hazards, potential consequences of fires, and the fire protection features. After reviewing licensee responses to the BTP, the staff determined that additional guidance on the management and administration of fire protection programs was necessary, and in mid-1977, issued Generic Letter 77-002, which provided criteria used by the staff in review of specific elements of a licensee's fire protection program, including organization, training, combustible and ignition source controls, firefighting procedures and quality assurance. Many fire protection issues were resolved during the BTP review process, and agreements were included in the NRC-issued safety evaluation reports (SERs).

By the late 1970s to early 1980, the majority of operating plants had completed their analyses and implemented most of the fire protection program guidance and recommendations specified in Appendix A to the BTP. In most cases, the NRC had found the licensees' proposed modifications resulting from these analyses to be acceptable. In certain instances, however, technical disagreements between licensees and the NRC staff led to some licensees' opposition to adopt some of the specified fire protection recommendations, such as the requirements for fire brigade size and training; water supplies for fire suppression systems; alternative, dedicated, or backup shutdown capability; emergency lighting; qualifications of penetration seals used to enclose places where cables penetrated fire barriers; and the prevention of reactor coolant pump oil system fires. Following deliberation, the Commission determined that, given the generic nature of some of the disputed issues, a rulemaking was necessary to ensure proper implementation of NRC fire protection requirements.

In November 1980, the NRC published the "Fire Protection" rule, 10 CFR 50.48, which specified broad performance requirements, as well as Appendix R, “Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979," to 10 CFR Part 50, which specified detailed regulatory requirements for resolving the disputed issues.

As originally proposed (Federal Register, Vol. 45, No. 1&5, May 22, 1980), Appendix R would have applied to all plants licensed prior to January 1, 1979, including those for which the staff had previously accepted the fire protection features as meeting the provisions of Appendix A to APCSB 9.5-1. After analyzing comments on the proposed rule, the Commission determined that only three of the fifteen items in Appendix R were of such safety significance that they should apply to all plants (licensed prior to January 1, 1979), including those for which alternative fire protection actions had been approved previously by the staff. These items are fire protection of safe shutdown capability (including alternative, dedicated, or backup shutdown systems), emergency lighting, and the reactor coolant pump oil system. Accordingly, the final rule required all reactors licensed to operate before January 1, 1979, to comply with these three items even if the NRC had previously approved alternative fire protection features in these areas (Federal Register, Vol. 45, Nov. 19, 1980). In addition, the rule provided an exemption process that can be requested by a licensee provided that a required fire protection feature to be exempted would not enhance fire protection safety in the facility or that such modifications may be detrimental to overall safety (10 CFR 50.48(c)(6)). Under this process, if the Director, Office of Nuclear Reactor Regulation, determined that a licensee has made a prima facie showing of a sound technical basis for such an assertion, then the implementation dates of the rule were delayed until final Commission action on the exemption request. Appendix R to 10 CFR Part 50 and 10 CFR 50.48 became effective on February 17, 1981.

During the initial backfit of the fire protection regulation, the NRC approved a large number of plant-specific exemptions (i.e., alternative methods to achieve the underlying purpose of the regulation) at about 60 nuclear power plants. Since the mid-1980s, as licensees’ programs became more compliant with the fire protection regulations, the number of exemptions requested and approved has decreased. Even so, the ongoing review of licensee fire protection programs, the licensee efforts to save costs while maintaining an acceptable level of safety, and the emergence of additional technical issues (such as the deliberations over the adequacy of Thermo-Lag as a fire protection barrier) have resulted in several hundred exemptions to specific elements of the NRC fire protection requirements. This progression, the broad provisions of the general design criterion, the detailed implementing guidance, the plant-by-plant review, and finally the issuance and backfit of the fire protection regulation and the prescriptive requirements of Appendix R resulted in a complex regulatory framework for fire protection in U.S. nuclear power plants licensed prior to 1979 and resulted in the issuance of a number of additional guidelines, clarifications, and interpretations, primarily as generic letters. Plants licensed after January 1, 1979, were not required to meet the provisions of Appendix R unless specified in specific license conditions. These plants were typically reviewed to the guidelines of Section 9.5.1 of the Standard Review Plan (NUREG-0800), which subsumed the criteria specified in Appendix R. In July 1981, the NRC issued a major revision to NUREG-0800 for use in review of new license applications. This revision included Standard Review Plan Section 9.5.1 with Branch Technical Position CMEB 9.5-1 as an update to the earlier fire protection BTPs.

Following promulgation of 10 CFR 50.48 and Appendix R, the staff issued Generic Letter 81-12 (February 20, 1981) and later its associated clarification letter (March 22, 1982). In these letters, the staff identified the information necessary to perform their reviews of licensee compliance with the alternative or dedicated shutdown requirements of Section III.G.3 of Appendix R. Staff guidance provided in these letters defined safe shutdown objectives, reactor performance goals, necessary safe shutdown systems and components, and associated circuit identification and analysis methods. Generic Letter 81-12 also requested that technical specifications be developed for safe shutdown equipment that was not already included in the existing plant technical specifications.

Most licensees requested and were granted additional time to perform their reanalysis, propose modifications to improve post fire safe shutdown capability, and identify exemptions for certain fire protection configurations. In reviewing some exemption requests, the staff noted that a number of licensees had made significantly different interpretations of certain requirements. These differences were identified in the staff's draft SERs and were discussed on several occasions with the cognizant licensees. These discussions culminated in the issuance of Generic Letter 83-33 (October 19, 1983).

Certain licensees disagreed with, or found it difficult to implement, the interpretations provided in Generic Letter 83-33. To pursue the matter with senior NRC management, the industry formed the Nuclear Utility Fire Protection Group. Subsequently, the staff formed the Steering Committee on Fire Protection Policy.

Following staff inspections of operating plants, which identified a number of significant items of non-compliance, and disagreements in the implementation of interpretations provided in Generic Letter 83-33, the Nuclear Utility Fire Protection Group requested interpretations of certain Appendix R requirements and provided a list of questions to be discussed with the industry. The NRC responded by holding workshops in each Region to assist the industry in understanding the NRC’s requirements and to improve the staff’s understanding of the industry’s concerns. The results of these workshops and the Steering Committee’s findings and recommendations for addressing ongoing fire protection issues were documented in Generic Letter 85-01. Generic Letter 85-01 included a proposed Generic Letter that provided additional interpretations related to compliance with Appendix R and staff answers to the industry’s list of questions from the workshops. This proposed Generic Letter was revised and later issued as Generic Letter 86-10, “Implementation of Fire Protection Requirements,” on April 24, 1986.

Also included in Generic Letter 86-10 was a “standard license condition” for adoption by licensees. Through the implementation and adoption of a standard license condition, a licensee was allowed to make changes to its fire protection program without prior notification to the NRC in accordance with the provisions of 10 CFR 50.59, provided the changes did not adversely affect the plant’s ability to achieve and maintain post-fire safe shutdown. The licensee, upon modification of the license to adopt the standard condition, could also amend the license to remove the fire protection technical specifications. Generic Letter 88-12, “Removal of Fire Protection Requirements from Technical Specifications” (August 2, 1988), gave licensees additional guidance for implementation of the standard license condition and removal of the technical specifications associated with fire detection and suppression, fire barriers, and fire

brigade staffing. The technical specifications associated with safe shutdown equipment and the administrative controls related to fire protection audits were to be retained under the guidance of the generic letter.

As illustrated in the preceding discussion, the Commission's fire protection requirements and guidelines consist of a multitude of rules, generic communications, staff guidance, and other related documents. Current industry and regulatory issues have prompted action on the part of the NRC to compile the current fire protection regulations and guidelines for operating reactors into this comprehensive guide.

REGULATORY REQUIREMENTS

There are a number of regulatory requirements with applicability to the development and implementation of fire protection programs for nuclear power plants currently operating as of January 1, 2001. The primary requirements are summarized in this section.

Appendix A to 10 CFR Part 50

Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 establishes for those plants for which its provisions apply, the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components important to safety (see Glossary). The following subsections summarize those GDC with specific application to fire protection of nuclear power plants.

GDC 3, Fire Protection

GDC 3 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, particularly in locations such as the containment and control room. Fire detection and fighting systems of appropriate capacity and capability are required to be provided and designed to minimize the adverse effects of fires on structures, systems, and components important to safety. GDC 3 also requires 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.

GDC 5, Sharing of Structures, Systems, and Components

GDC 5 requires that structures, systems, and components important to safety not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

GDC 19, Control Room

GDC 19 requires that a control room be provided from which actions can be taken to operate the nuclear power unit under normal and accident conditions, while limiting radiation exposure to control room personnel under accident conditions for the duration of the accident. GDC 19 also requires that equipment and locations outside the control room be provided with the design capability to accomplish hot shutdown of the reactor and with a potential capability for subsequent cold shutdown of the reactor.

GDC 23, Protection System Failure Modes

GDC 23 requires that the protection system be designed to fail into a safe state or into a state demonstrated to be acceptable on some other defined basis if conditions such as disconnection of the system, loss of energy (e.g., electric power, instrument air), or postulated adverse environments (e.g., extreme heat or cold, fire, pressure, steam, water, radiation) are experienced.

10 CFR 50.48

Section 50.48 of 10 CFR Part 50 requires that each operating nuclear power plant have a fire protection plan that satisfies General Design Criterion 3 of Appendix A to 10 CFR Part 50. It specifies what should be contained in such a plan and lists the basic fire protection guidelines for the plan.

Section 50.48 also requires that all plants with operating licenses prior to January 1, 1979, satisfy the requirements of Sections III.G, III.J, and III.O, and other sections of Appendix R to 10 CFR Part 50, where approval of similar features had not been obtained prior to the effective date of Appendix R.

Plants licensed to operate after January 1, 1979, must meet the provisions of 10 CFR 50.48(a).

As discussed later in this guide in the Licensing and Design Basis section, deviations from NRC fire protection requirements are documented and reviewed under different processes depending on the date of the operating license. Appendix R requirements for pre-1979 plants are processed under the exemption process. Deviations from other applicable guidelines are identified and evaluated in the staff's Safety Evaluation Reports. For post-1979 plants, where fire protection features do not meet applicable NRC requirements or commitments, or alternative approaches are proposed, the condition is documented as a deviation.

Appendix R to 10 CFR Part 50

Appendix R to 10 CFR Part 50 applies to licensed nuclear power electric generating stations that were operating prior to January 1, 1979, except as noted in 10 CFR 50.48(b). With respect to certain generic issues for such facilities, Appendix R identifies fire protection features

required to satisfy Criterion 3 of Appendix A. There are two categories of Appendix R provisions that are applicable to the fire protection features of these facilities.

The first category consists of those provisions that were required to be backfit in their entirety, regardless of whether alternatives to the specific requirements had been previously approved by the NRC. The requirements are identified in Sections III.G, “Fire Protection of Safe Shutdown Capability”; III.J, “Emergency Lighting”; and III.O, “Oil Collection System for Reactor Coolant Pump.” Those plants subject to the requirements of Section III.G.3 must also meet the requirements of Section III.L.

The second category consists of requirements concerning the open items of previous NRC staff fire protection reviews. Open items are defined as fire protection features that had not been previously approved by the NRC staff as satisfying the provisions of Appendix A to APCSB 9.5-1, as reflected in SERs.

Except as specified in the license conditions of individual plants, Appendix R was not required to be implemented by plants that were licensed to operate after January 1, 1979. Rather, fire protection programs at these later plants were typically reviewed against the licensing review guidelines of Section 9.5-1 to the Standard Review Plan (NUREG-0800). SRP Section 9.5-1 and the associated CMEB 9.5-1 consolidated the guidance of the previous BTP, Appendix A to APCSB 9.5-1, Appendix R, and other staff guidance.

10 CFR Parts 50.72 and 50.73

These regulations prescribe the notification and reporting requirements for nuclear power plant licensees, including those related to fire protection programs. Section 50.72 provides for immediate notification requirements via the emergency notification system (ENS), and Section 50.73 provides for 60-day written licensee event reports (LERs).

The information reported under 10 CFR 50.72 and 50.73 is used by the NRC staff in responding to emergencies, monitoring ongoing events, confirming licensing bases, studying potentially generic safety problems, assessing trends and patterns of operational experience, monitoring performance, identifying precursors of more significant events, and providing operational experience to the industry. The two rules have identical reporting thresholds and similar language whenever possible. They are complementary and of equal importance, with necessary dissimilarities in reporting requirements to meet their different purposes.

The regulation, 10 CFR 50.72, is structured to provide telephone notification of reportable events to the NRC Operations Center within a time frame established by the relative importance of the events. Events are categorized as either emergencies (immediate notifications, but no later than 1 hour) or non-emergencies. Non-emergencies are further categorized into 1-hour and 4-hour notifications; non-emergency events requiring 4-hour notifications generally have slightly less urgency and safety significance than those requiring 1-hour notifications. Immediate telephone notification to the NRC Operations Center of declared emergencies is necessary so the NRC may immediately respond. Reporting of non-emergency events and conditions is necessary

to permit timely NRC follow-up via event monitoring, special inspections, generic communications, or resolution of public or media concerns.

According to 10 CFR 50.73, written LERs must be submitted on reportable events within 60 days of their occurrence, after a thorough analysis of the event, its root causes, safety assessments, and corrective actions are available, to permit NRC engineering analyses and studies.

LICENSING AND DESIGN BASIS

The fire protection licensing and design basis is dependent on a number of factors that may differ considerably for individual plants. However, with the issuance of the fire protection rule, 10 CFR 50.48, and Appendix R to 10 CFR 50, the applicability of certain fire protection requirements, including those within the rule, was established on the basis of the licensing date for a given plant being before or after January 1, 1979.

Plants Licensed Prior to January 1, 1979

The primary licensing basis for plants licensed to operate prior to January 1, 1979, is comprised of the plant license conditions, Appendix R and any approved exemptions, and the staff's Safety Evaluation Reports (SERs) on the fire protection program.

Safety Evaluation Reports

The SERs document the staff acceptance of the plant fire protection program or elements thereof. For plants licensed to operate prior to January 1, 1979, the staff's SERs also establish the extent to which the requirements of Appendix R to 10 CFR Part 50 apply. Plants whose fire protection features were accepted by the NRC as satisfying the provisions of Appendix A to Branch Technical Position (BTP) APCSB 9.5-1, or were accepted in comprehensive SERs issued prior to publication of Appendix A to BTP APCSB 9.5-1 in August 1976, were only required to meet the provisions of Sections III.G (III.L), III.J, and III.O of Appendix R.

Exemptions to Appendix R

Effective February 17, 1981, the NRC amended its regulations by adding 10 CFR 50.48 and Appendix R to 10 CFR Part 50, requiring certain provisions for fire protection in nuclear power plants licensed to operate before January 1, 1979.

Plants with previously approved fire protection features (see Safety Evaluation Reports above) were exempted from the requirements of Appendix R with the exception of Sections III.G, III.J, and III.O.

The required schedules for licensees to comply with the provisions of Appendix R were established in 10 CFR 50.48(c). Provisions were also included in the rule to allow licensees to file exemptions from Appendix R requirements on the basis that the required modifications would not enhance fire protection safety in the facility or would be detrimental to overall facility safety. These exemptions, upon approval by the staff, become a part of the fire protection licensing basis. The provisions of 10 CFR 50.48(c) have since expired and have been deleted from the regulations.

Future exemptions should be requested in accordance with 10 CFR 50.12, as discussed below. (See Regulatory Position 1.8.2.)

Exemptions from fire protection requirements may also be requested in accordance with the provisions of 10 CFR 50.12. Under 10 CFR 50.12, the Commission may grant exemptions from the requirements of the regulations in 10 CFR Part 50, which are:

1. Authorized by law, will not present an undue risk to the public health and safety, and are consistent with the common defense and security.

2. The Commission will not consider granting an exemption unless special circumstances are present. Special circumstances are present whenever;

- Application of the regulation in the particular circumstances conflicts with other rules or requirements of the Commission; or

- Application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule; or

- Compliance would result in undue hardship or other costs that are significantly in excess of those contemplated when the regulation was adopted, or that are significantly in excess of those incurred by others similarly situated; or

- The exemption would result in benefit to the public health and safety that compensates for any decrease in safety that may result from the grant of the exemption; or

- The exemption would provide only temporary relief from the applicable regulation and the licensee or applicant has made good faith efforts to comply with the regulation; or

- There is present any other material circumstance not considered when the regulation was adopted for which it would be in the public interest to grant an exemption. If such condition is relied on exclusively for satisfying criteria (2) above, the exemption may not be granted until the Executive Director for Operations has consulted with the Commission.

Operating License Conditions

Most operating plant licenses contain a section on fire protection. License conditions for plants licensed prior to January 1, 1979, typically contain a condition requiring implementation of modifications committed to by the licensee as a result of the fire protection program review with respect to the branch technical position. These license conditions were added by amendments issued between 1977 and February 17, 1981, the effective date of 10 CFR 50.48 and Appendix R.

As a result of numerous compliance, inspection, and enforcement issues associated with the various plant license conditions, the staff developed a standard licensing condition. The standard license condition, and the NRC's recommendation that it be adopted by licensees, was transmitted to licensees in Generic Letter 86-10. Additional guidance regarding removal of the fire protection requirements from the plant technical specifications was provided to licensees in Generic Letter 88-12. The changes were promulgated to provide licensees greater flexibility in the management and implementation of the fire protection program and to clarify the fire protection licensing basis for the specific facility.

Plants Licensed After January 1, 1979

Plants licensed after January 1, 1979, are subject to the requirements of 10 CFR 50.48(a) only, and as such must meet the provisions of GDC 3 as specified in their license conditions and as accepted by the NRC in their SERs. These plants are typically reviewed to the guidance of SRP Section 9.5-1. For these plants, where commitments to specific guidelines cannot be met, or alternative approaches are proposed, the differences between the licensee's program and the guidelines are documented in deviations (see Regulatory Position 1.4.4).

FIRE PROTECTION PROGRAM GOALS/OBJECTIVES

Defense in Depth

Fire protection for nuclear power plants uses the concept of defense in depth to achieve the required degree of reactor safety by using echelons of administrative controls, fire protection systems and features, and safe shutdown capability. These defense-in-depth principles are aimed at achieving the following objectives.

- To prevent fires from starting,
- To detect rapidly, control, and extinguish promptly those fires that do occur, and
- To provide protection for structures, systems, and components important to safety so that a fire that is not promptly extinguished by the fire suppression activities will not prevent the safe shutdown of the plant.

Assumptions

Postulated Fire

Fire damage to safe shutdown equipment is assessed on the basis of a single fire, including an exposure fire. An exposure fire is a fire in a given area that involves either in situ or transient combustibles and has the potential to affect structures, systems, and components important to safety located in or adjacent to that same area. The effects of such fire (e.g., smoke, heat, or ignition) can adversely affect those structures, systems, and components important to safety. Thus, a fire involving one success path of safe shutdown equipment may constitute an exposure fire for the redundant success path located in the same area, and a fire involving combustibles other than

either redundant success path may constitute an exposure fire to both redundant success paths located in the same area.

Three levels of fire damage limits are established according to the safety function of the structure, system, or component. Damage limits for hot shutdown and cold shutdown systems and components are described in Regulatory Positions 5.3 and 5.4, respectively. Redundant systems necessary for mitigation of consequences following design basis accidents, but not required for safe shutdown may be damaged by a single exposure fire as discussed below in the Safety-Related Structures, Systems, and Components section.

The most stringent fire damage limit should apply for those systems that fall into more than one category.

The fire event for considering the need for alternative or dedicated shutdown is a postulated fire in a specific fire area containing redundant safe shutdown cables/equipment where it has been determined that fire protection means specified in Regulatory Position 5.5 cannot be provided to ensure that safe shutdown capability will be preserved.

Conditions of Fire Occurrence

It is assumed that a fire may occur at any time, but is not postulated to occur simultaneously with plant accidents or the most severe natural phenomena.

On multiple reactor sites, unrelated fires in two or more units need not be postulated to occur simultaneously. Fires involving facilities shared between units and fires caused by man-made 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.

Loss of Offsite Power/Station Blackout

In evaluating the capability to accomplish post-fire safe shutdown, offsite power may or may not be available and consideration should be given to both cases. However, loss of offsite power need not be considered for a fire in non-alternative or dedicated shutdown areas if it can be shown that offsite power cannot be lost due to a fire in that area.

In accordance with the guidelines in Regulatory Position 5.6 of this guide, the capability to accomplish safe shutdown should be demonstrated for a loss of offsite power with a duration of 72 hours. However, in evaluating safe shutdown circuits, including associated circuits, the availability of uninterrupted power (i.e., offsite power available) may impact the ability to control the safe shutdown of the plant by increasing the potential for associated circuit interactions resulting from fire damage to energized power and control circuits.

Several licensees have alternative post-fire safe shutdown methodologies that may result in loss of all ac power (i.e., station blackout). Some of these plants voluntarily enter station blackout (SBO) as a means to cope with the potential for spurious operations and to provide positive (manual) control of safe shutdown equipment. Others have procedures that may cause a SBO condition to be created as a result of fire effects (e.g., procedures that direct operators to manually

trip the credited safe shutdown emergency diesel generator (EDG) in the event of fire damage to circuits of vital EDG support systems).

The ability to cope with SBO as part of the post-fire safe shutdown methodology is dependent on such issues as timeline logic; assumptions and bases for plant and operator response relative to component realignment; the ability of plant operators to monitor and control plant parameters and align plant components before, during, and after SBO control room evacuation and abandonment; and the practicality and reliability of EDG start and load (and restart, if applicable) under post-fire safe shutdown SBO conditions. The relative risk of self-imposed SBO may greatly exceed the actual risk posed by the fire and should be given appropriate consideration when evaluating the plant safe shutdown design and procedures.

Fragility of Structures, Systems, and Components to Fire Damage

Fire damage to structures, systems, and components can result from heat, smoke, or ignition. Fire is assumed to damage safe shutdown structures, systems, and components within the fire area of concern as discussed in the Postulated Fire section above and subject to the guidelines in Regulatory Positions 5.3 and 5.4 of this guide and as determined by the fire hazards analysis. When using a performance-based or risk-informed alternative approach, the fragility of structures, systems, and components to fire damage, including the ability to repair affected structures, systems, and components, should be considered.

Fire Protection Program Performance Goals

Safety-Related Structures, Systems, and Components

Because fire may affect safe shutdown systems, and because the loss of function of systems used to mitigate the consequences of design basis accidents under post-fire conditions does not per se impact public safety, the need to limit fire damage to systems required to achieve and maintain safe shutdown conditions is greater than the need to limit fire damage to those systems required to mitigate the consequences of design basis accidents.

Post-Fire Safe Shutdown

The performance objectives of the fire protection program relative to post-fire safe shutdown are to ensure that one success path of structures, systems, and components necessary for hot shutdown is free of fire damage, and to limit fire damage such that one success path of structures, systems, and components necessary to achieve and maintain cold shutdown can be repaired or made operable within a specified time period using onsite capabilities (see Regulatory Position 5.3).

Prevention of Radiological Release

The fire protection program, including the fire hazards analysis, should demonstrate that the plant will maintain the ability to minimize the potential for radioactive releases to the environment in the event of a fire. Fires are expected to occur over the life of a nuclear power plant and thus should be treated as anticipated operational occurrences. Requirements for protection against radiation during normal operations are in 10 CFR Part 20. Anticipated operational occurrences should not result in radiological consequences, and the exposure criteria of 10 CFR Part 20 apply.

Post-Fire Safe Shutdown Reactor Safety/Performance Goals

Power Operations

One success path of cables and equipment necessary to achieve and maintain hot shutdown is to be maintained free of fire damage. The reactor safety and performance goals for post-fire safe shutdown should ensure that the specified acceptable fuel design limits are not exceeded. Post-fire reactor safety and performance goals for alternative or dedicated shutdown are specified in Section III.L of Appendix R to 10 CFR 50.

Shutdown/Refueling Operations

During shutdown operations, particularly during maintenance or refueling outages, fire conditions can change significantly as a result of work activities. Redundant systems important to safety may not be available as allowed by plant Technical Specifications and plant procedures. Fire protection during shutdown or refueling conditions should minimize the potential for fire events to impact safety functions (e.g., reactivity control, reactor decay heat removal, spent fuel pool cooling), or result in the release of radioactive materials, under the differing conditions that may be present during these operations.

C. REGULATORY POSITION

1. FIRE PROTECTION PROGRAM

In accordance with 10 CFR 50.48, a fire protection program must be established at each nuclear power plant. The program should establish the fire protection policy for the protection of structures, systems, and components important to safety at each plant and the procedures, equipment, and personnel required to implement the program at the plant site.

The fire protection program should extend the concept of defense in depth to fire protection in fire areas important to safety, with the following objectives.

- To prevent fires from starting;
- To detect rapidly, control, and extinguish promptly those fires that do occur;
- To provide protection for structures, systems, and components important to safety so that a fire that is not promptly extinguished by the fire suppression activities will not prevent the safe shutdown of the plant.

In accordance with 10 CFR 50.48, the fire protection program must:

- Identify the various positions within the licensee’s organization that are responsible for the program and state the authorities delegated to these positions (see Regulatory Position 1.1);

- Describe specific features such as administrative controls and personnel requirements for fire prevention (see Regulatory Position 2);

- Outline the plans for fire detection and suppression capability, and limitation of fire damage (see Regulatory Positions 1.2, 3, and 4);

- Describe personnel requirements for manual fire suppression activities (see Regulatory Position 3.5); and

- Describe the means to limit fire damage to structures, systems, and components important to safety so that capability to safely shut down the plant is ensured (see Regulatory Positions 1.3 and 5).

On reactor sites with an operating reactor and with construction, modification, or decommissioning of other units under way, the fire protection program should provide for continuing evaluation of fire hazards associated with these activities. Additional fire barriers, fire protection capability, and administrative controls should be provided as necessary to protect the operating unit from construction or decommissioning fire hazards.

The guidance in Regulatory Position 1 is based on 10 CFR 50.48, Appendix R to 10 CFR Part 50, and CMEB 9.5-1.

1.1 Organization, Staffing, and Responsibilities

The fire protection program should be under the direction of an individual who has been delegated authority commensurate with the responsibilities of the position and who has available staff personnel knowledgeable in both fire protection and nuclear safety.

Responsibility for the overall fire protection program should be assigned to a person who has management control over all organizations involved in fire protection activities. Formulation and assurance of program implementation may be delegated to a staff composed of personnel prepared by training and experience in fire protection and personnel prepared by training and experience in nuclear plant safety to provide a comprehensive approach in directing the fire protection program for the nuclear power plant.

The following positions or organizations should be designated.

a. The upper level management position that has management responsibility for the formulation, implementation, and assessment of the effectiveness of the nuclear plant fire protection program.

b. The management positions directly responsible for formulating, implementing, and periodically assessing the effectiveness of the fire protection program for the licensee's nuclear power plant, including fire drills and training conducted by the fire brigade and plant personnel. The results of these assessments should be

reported to the upper level management position responsible for fire protection with recommendations for improvements or corrective actions as deemed necessary.

c. The onsite management position responsible for the overall administration of the plant operations and emergency plans that include the fire protection and prevention program and that provide a single point of control and contact for all contingencies. On sites with an operating reactor and with construction, modification, or decommissioning of other units under way, the superintendent of the operating plant should have the lead responsibility for site fire protection.

d. The onsite positions that:

   i. Implement periodic inspections to minimize the amount of combustibles in plant areas important to safety; determine the effectiveness of housekeeping practices; ensure the availability and acceptable condition of all fire protection systems/equipment, emergency breathing apparatus, emergency lighting, communication equipment, fire stops, penetration seals, and fire retardant coatings; and ensure that prompt and effective corrective actions are taken to correct conditions adverse to fire protection and preclude their recurrence.

   ii. Are responsible for the firefighting training for operating plant personnel and the plant's fire brigade, design and selection of equipment, periodic inspection and testing of fire protection systems and equipment in accordance with established procedures, and evaluation of test results and determination of the acceptability of the systems under test.

   iii. Assist in the critique of all fire drills to determine how well the training objectives have been met.

   iv. Are responsible for the in-plant fire protection review of proposed work activities to identify potential transient fire hazards and specify required additional fire protection in the work activity procedure.

   v. Implement a program for indoctrination of all plant contractor personnel in appropriate administrative procedures that implement the fire protection program and the emergency procedures relative to fire protection.

   vi. Implement a program for instruction of personnel on the proper handling of accidental events such as leaks or spills of flammable materials that are related to fire protection.

   vii. Are responsible for review of hot work.

e. The onsite position responsible for fire protection quality assurance. This position is responsible for ensuring the effective implementation of the fire protection program by planned inspections, scheduled audits, and verification that the results

of these inspections and audits are promptly reported to cognizant management personnel.

f. The positions that are part of the plant fire brigade (also see Regulatory Position 3.5.1).

   i. The plant fire brigade positions should be responsible for fighting fires. The authority and responsibility of each fire brigade position relative to fire protection should be clearly defined.

   ii. The responsibilities of each fire brigade position should correspond with the actions required by the firefighting procedures.

   iii. Collateral responsibilities of the fire brigade members should not conflict with their responsibilities related to the fire brigade during a fire emergency.

   iv. The minimum number of trained fire brigade members available onsite for each operating shift should be consistent with the activities required to combat credible and challenging fires, but no less than 5 members. The size of the fire brigade should be based upon the functions required to fight fires with adequate allowance for injuries. Fire brigade staffing should account for all operational and emergency response demands on shift personnel in the event of a significant fire.

The guidance in Regulatory Position 1.1 is based on CMEB 9.5-1, IN 91-77, IN 95-48, and Stello Letter to Bixel (1978).

1.2 Fire Hazards Analysis

A fire hazards analysis should be performed to demonstrate that the plant will maintain the ability to perform safe shutdown functions and minimize radioactive material releases to the environment in the event of a fire. This analysis should be revised as necessary to reflect plant design and operational changes.

The fire hazards analysis accomplishes the following objectives:

a. Considers potential in situ and transient fire hazards;

b. Determines the consequences of fire in any location in the plant on the ability to safely shut down the reactor or on the ability to minimize and control the release of radioactivity to the environment; and

c. Specifies measures for fire prevention, fire detection, fire suppression, and fire containment and alternative shutdown capability for each fire area containing structures, systems, and components important to safety in accordance with NRC guidelines and regulations.

The fire hazards analysis verifies that the NRC fire protection program guidelines have been met. The analysis lists applicable elements of the program, with explanatory statements as needed to identify location, type of system, and design criteria. The analysis should identify and justify any deviations from the regulatory guidelines. Justification for deviations from the regulatory guidelines should show that an equivalent level of protection will be achieved (see Regulatory Position 1.8 regarding when such deviations are subject to the exemption request process). Deletion of a protective feature without compensating alternative protection measures is typically unacceptable, unless it is clearly demonstrated that the protective measure is not needed because of the design and arrangement of the particular plant.

The fire hazards analysis should address the following elements and attributes.

- The NRC fire protection requirements and guidance that apply.

- Amounts, types, configurations, and locations of cable insulation and other combustible materials.

- In situ fire hazards.

- Automatic fire detection and suppression capability. The effects of lightning strikes should be included in the design of fire detection systems.

- Layout and configurations of structures, systems, and components important to safety. The protection for safe shutdown systems (see Regulatory Positions 5.5 and 5.6) within a fire area should be determined on the basis of the worst case fire that is likely to occur and the resulting damage. The extent of such damage should be justified in the fire hazards analysis. The analysis should consider the degree of spatial separation between redundant shutdown systems, the presence of in situ and transient combustibles, the available fire protection systems and features, sources of ignition, and the susceptibility to fire damage of the safe-shutdown-related cables, equipment, systems, and features in the area.

- Reliance on and qualifications of fire barriers, including fire test results, the quality of the materials and barrier system, and the quality of the barrier installation.

- Fire area construction (walls, floor, ceiling, dimensions, volume, ventilation, and congestion). The fire hazard analysis should be the mechanism to determine that fire areas have been properly selected. Guidelines for fire areas and zones are provided in Regulatory Position 4.1.2 of this guide.

- Location and type of manual firefighting equipment and accessibility for manual fire fighting.

- Potential disabling effects of fire suppression systems on shutdown capability. The term "damage by fire" in Appendix R also includes damage to equipment from the

normal or inadvertent operation of fire suppression systems. The fire hazards analysis should address the effects of firefighting activities. GDC 3 of Appendix A to 10 CFR Part 50 states that "Fire-fighting systems shall be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components."

- Availability of oxygen (for example, inerted containment).

- Alternative, dedicated, or backup shutdown capability.

Fire initiation should be postulated at the location within each fire area/zone that will produce the most severe fire with the potential to adversely impact structures, systems, and components important to safety. 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.

"Worst case" 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.

On multiple-reactor sites, unrelated fires in two or more units need not be postulated to occur simultaneously. Fires involving facilities shared between units and fires caused by man-made 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.

The fire hazards analysis should separately identify hazards and provide appropriate protection in locations where losses of structures, systems, and components important to safety can occur as a result of the following.

1. Concentrations of combustible contents, including transient fire hazards of combustibles expected to be used in normal operations such as refueling, maintenance, and modifications,

2. Continuity of combustible contents, furnishings, building materials, or combinations thereof in configurations conducive to fire spread,

3. Exposures to fire, heat, smoke, or water, including those that may necessitate evacuation from areas that are required to be attended for safe shutdown,

4. Fire in control rooms or other locations having critical functions important to safety,

5. Lack of adequate access or smoke removal facilities that impede plant operations or fire extinguishment in plant areas important to safety,

6. Lack of explosion-prevention measures,

7. Loss of electric power or control and instrumentation circuits,

8. Inadvertent operation of fire suppression systems.

The fire hazards analysis should be performed by qualified fire protection and reactor systems engineers.

Experienced judgment is necessary to identify fire hazards and the consequences of a postulated fire starting at any location 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 with the qualifications in Regulatory Position 1.6.1.a.

The guidance in Regulatory Position 1.2 is based on GDC 3, Appendix R to 10 CFR Part 50, ASB 9.5-1, CMEB 9.5-1, GL 86-10, IN 83-41, and IN 86-106.

1.3 Safe Shutdown Analysis

In accordance with 10 CFR 50.48, each operating nuclear power plant must provide the means to limit fire damage to structures, systems, and components important to safety so that the capability to safely shut down the reactor is ensured.

A safe shutdown analysis should be developed that demonstrates the capability of the plant to safely shut down for a fire in any given area. The safe shutdown performance goals and reactor performance criteria applicable to safe shutdown are identified in Regulatory Positions 5.1 and 5.2 of this guide. Recommended systems and instrumentation for accomplishing safe shutdown are identified in Regulatory Positions 5.3 and 5.4 for hot shutdown and cold shutdown, respectively. The selected systems should be demonstrated to accomplish the safe shutdown functions within the fire damage guidelines of Regulatory Positions 5.3 and 5.4.

The analysis should identify the safe shutdown components and associated non-safety circuits for each fire area and demonstrate that the guidelines of Regulatory Position 5.5 are met or that alternative, dedicated, or backup shutdown is provided in accordance with Regulatory Position 5.6 of this guide. For each plant, the combinations of systems that provide the shutdown functions may be unique for each area; however, the shutdown functions provided should ensure that the safe shutdown performance objectives are achieved.

Procedures necessary to implement safe shutdown should also be developed and implemented as appropriate (see Regulatory Position 5.7).

1.4 Fire Test Reports and Fire Data

Fire reports and data (e.g., fire barrier testing results and cable derating data) that are used to demonstrate compliance with NRC fire protection requirements should be evaluated to ensure that the information is applicable and representative of the conditions for which the information is being applied.

NFPA 251, "Standard Methods of Tests of Fire Endurance of Building Construction and Materials," advises that the test conditions should be evaluated carefully because variations from the construction of the test specimen or from the condition in which it is tested may substantially change the performance characteristics of the tested assembly.

Relative to testing of fire barrier assemblies, not all possible configurations can be tested, and additional guidance is provided in Regulatory Positions 1.8.3 and 4.2 of this guide for evaluation of installed configurations that deviate from tested conditions.

The guidance in Regulatory Position 1.4 is based on GL 92-08.

1.5 Compensatory Measures

Temporary changes to specific fire protection features that may be necessary to accomplish maintenance or modifications are acceptable provided interim compensatory measures, such as fire watches, temporary fire barriers, or backup suppression capability, are implemented. For common types of deficiencies, the specific compensatory measures are generally noted in technical specifications or the NRC-approved fire protection program. For unique situations, the appropriate compensatory measures are determined by the licensee.

Compensatory measures may also be implemented for degraded and nonconforming conditions. In its evaluation of the impact of a degraded or nonconforming condition on plant operation and on operability of structures, systems, and components, a licensee may decide to implement a compensatory measure as an interim step to restore operability or to otherwise enhance the capability of structures, systems, and components until the final corrective action is complete. Reliance on a compensatory measure for operability should be an important consideration in establishing the "reasonable time frame" to complete the corrective action process. As stated in Revision 1 of GL 91-18, the NRC would normally expect that conditions that require interim compensatory measures to demonstrate operability would be resolved more promptly than conditions that are not dependent on compensatory measures to show operability, because such reliance suggests a greater degree of degradation. Similarly, if an operability determination is based upon operator action, the staff would expect the nonconforming condition to be resolved expeditiously.

The guidance in Regulatory Position 1.5 is based on CMEB 9.5-1, GL 86-10, GL 91-18, and IN 97-48.

1.6 Fire Protection Training and Qualifications

The fire protection program should be under the direction of an individual who has available staff personnel knowledgeable in both fire protection and nuclear safety. Plant personnel should be adequately trained in administrative procedures that implement the fire protection program and the emergency procedures relative to fire protection.

The guidance in Regulatory Position 1.6 is based on Appendix R to 10 CFR Part 50 and CMEB 9.5-1.

1.6.1 Fire Protection Staff Training and Qualifications

Fire protection staff should meet the following:

a. The formulation and assurance of the fire protection program and its implementation should be the responsibility of personnel prepared by training and experience in fire protection and in nuclear plant safety to provide a comprehensive approach in directing the fire protection program for the nuclear power plant. A fire protection engineer (or a consultant) who is a graduate of an engineering curriculum of accepted standing and satisfies the eligibility requirements as a Member in the Society of Fire Protection Engineers should be a member of the organization responsible for formulation and implementation of the fire protection program.

b. The fire brigade members' qualifications should include satisfactory completion of a physical examination for performing strenuous activity and the fire brigade training described in Regulatory Position 1.6.4.

c. The personnel responsible for the maintenance and testing of the fire protection systems should be qualified by training and experience for such work.

d. The personnel responsible for the training of the fire brigade should be qualified by knowledge, suitable training, and experience for such work.

The guidance in Regulatory Position 1.6.1 is based on CMEB 9.5-1.

1.6.2 General Employee Training

Each nuclear plant employee has a responsibility in the prevention, detection, and suppression of fires. Site general employee training should introduce all personnel to the elements of the site fire protection program, including the responsibilities of the fire protection staff. Instruction should be provided on types of fires and related extinguishing agents, specific fire hazards at the site, and actions in the event of a fire suppression system actuation.

General employee training should provide specific instruction to site and contractor personnel on the following:

- Appropriate actions to take upon discovering a fire, including, for example, notification of the control room, attempt to extinguish fire, and actuation of local fire suppression systems.

- Actions upon hearing a fire alarm;
- Administrative controls on the use of combustibles and ignition sources; and
- The actions necessary in the event of a combustible liquid spill or gas release/leaks.

The guidance in Regulatory Position 1.6.2 is based on IP 64704.

1.6.3 Fire Watch Training

Fire watches provide for observation and control of fire hazards associated with hot work, or they may act as compensatory measures for degraded fire protection systems and features. Specific fire watch training should provide instruction on fire watch duties, responsibilities, and required actions for both 1-hour roving and continuous fire watches. Fire watch qualifications should include hands-on training on a practice fire with the extinguishing equipment to be used while on fire watch. If fire watches are to be used as compensatory actions, the fire watch training should include record-keeping requirements.

The guidance in Regulatory Position 1.6.3 is in GL 93-03 and IP 64704.

1.6.4 Fire Brigade Training and Qualifications

The fire brigade training program should ensure that the capability to fight credible and challenging fires is established and maintained. The program should consist of initial classroom instruction followed by periodic classroom instruction, firefighting practice, and fire drills (see Regulatory Position 3.5.1.4 for drill guidance).

Numerous NFPA standards provide guidelines applicable to the training of fire brigades. The training recommendations of NFPA 600, "Industrial Fire Brigades," including the applicable NFPA publications referenced in NFPA 600, are considered appropriate criteria for training of the plant fire brigade. NFPA 1410, "Standard on Training for Initial Fire Attack," may also be used as applicable. NFPA booklets and pamphlets listed in NFPA 600 may be used as applicable for training references. In addition, courses in fire prevention and fire suppression that are recognized or sponsored by the fire protection industry should be used.

1.6.4.1 Qualifications. The brigade leader and at least two brigade members should have sufficient training in or knowledge of plant systems to understand the effects of fire and fire suppressants on safe shutdown capability. The brigade leader should be competent to assess the potential safety consequences of a fire and advise control room personnel. Such competence by the brigade leader may be evidenced by possession of an operator's license or equivalent knowledge of plant systems. Nuclear power plants staffed with a dedicated professional fire department may utilize a fire team advisor to assess the potential safety consequences of a fire and advise the control room and incident commander. The fire team advisor should possess an operator's license or equivalent knowledge of plant systems and be dedicated to supporting the fire incident commander during fire emergency events.

The qualification of fire brigade members should include an annual physical examination to determine their ability to perform strenuous firefighting activities.

1.6.4.2 Instruction. The instruction should be provided by qualified individuals who are knowledgeable, experienced, and suitably trained in fighting the types of fires that could occur in the plant and in using the types of equipment available in the nuclear power plant. Instruction should be provided to all fire brigade members and fire brigade leaders.

The initial classroom instruction should include:

a. Indoctrination of the plant firefighting plan with specific identification of each individual's responsibilities.

b. Identification of the type and location of fire hazards and associated types of fires that could occur in the plant.

c. The toxic and corrosive characteristics of expected products of combustion.

d. Identification of the location of firefighting equipment for each fire area and familiarization with the layout of the plant, including access and egress routes to each area.

e. The proper use of available firefighting equipment and the correct method of fighting each type of fire:

- Fires involving radioactive materials,
- Fires in energized electrical equipment,
- Fires in cables and cable trays,
- Hydrogen fires,
- Fires involving flammable and combustible liquids or hazardous process chemicals,
- Fires resulting from construction or modifications (welding), and
- Record file fires.

f. The proper use of communication, lighting, ventilation, and emergency breathing equipment.

g. The proper method for fighting fires inside buildings and confined spaces.

h. The direction and coordination of the firefighting activities (fire brigade leaders only).

i. Detailed review of firefighting strategies and procedures.

j. Review of the latest plant modifications and corresponding changes in firefighting plans.

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.

Instruction 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.

Regular planned meetings should be held at least quarterly for all brigade members to review changes in the fire protection program and other subjects as necessary.

Periodic refresher training sessions should be held to repeat the classroom instruction program for all brigade members over a two-year period. These sessions may be concurrent with the regular planned meetings.

Retraining or broadened training for fire fighting within buildings should be scheduled for all those brigade members whose performance records show deficiencies.

1.6.4.3 Fire Brigade Practice. Practice sessions should be held for each shift fire brigade on the proper method of fighting the various types of fires that could occur in a nuclear power plant. These sessions should provide brigade members with experience in actual fire extinguishment and the use of self-contained breathing apparatus under strenuous conditions encountered in fire fighting. These practice sessions should be provided at least once per year for each fire brigade member.

1.6.4.4 Fire Brigade Training Records. Individual records of training provided to each fire brigade member, including drill critiques, should be maintained for at least 3 years to ensure that each member receives training in all parts of the training program. These records of training should be available for NRC review.

The guidance in Regulatory Position 1.6.4 is based on Appendix R to 10 CFR Part 50, APCSB 9.5-1, and CMEB 9.5-1.

1.7 Quality Assurance

The quality assurance (QA) program for fire protection should be part of the overall plant QA program. For fire protection systems, the licensee should have and maintain a QA program that provides assurance that the fire protection systems are designed, fabricated, erected, tested, maintained, and operated so that they will function as intended. Fire protection systems are not "safety-related" and are therefore not within the scope of Appendix B to 10 CFR Part 50, unless the licensee has committed to include these systems under the Appendix B program for the plant. NRC guidance for an acceptable QA program for fire protection systems, previously given in Section C.4 of Branch Technical Position CMEB 9.5-1, Rev. 2, dated July 1981, was generally used in the review and acceptance of approved fire protection programs for plants licensed after January 1, 1979. For plants licensed prior to January 1, 1979, similar guidance is specified in APCSB 9.5-1 and Appendix A thereto and in Generic Letter 77-02, "Nuclear Plant Fire Protection Functional Responsibilities, Administrative Controls and Quality Assurance."

The QA program should be under the management control of the QA organization. This control consists of (1) formulating and/or verifying that the fire protection QA 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.

To implement the Fire Protection QA Program in this Regulatory Position, licensees have the option of either (1) including the fire protection QA program as part of the plant's overall QA program under Appendix B to 10 CFR Part 50 or (2) providing for NRC review a description of the fire protection QA program and the measures for implementing the program.

The fire protection QA program should satisfy the specific criteria. These criteria apply to items within the scope of the fire protection program, such as fire protection systems and features, emergency lighting, communication and self-contained breathing apparatus, as well as the fire protection requirements of applicable equipment important to safety.

1.7.1 Design and Procurement Document Control

Measures should be established to include the guidance of this guide in design and procurement documents and that deviations therefrom are controlled such that:

a. Design and procurement document changes, including field changes and design deviations, are subject to the same level of controls, reviews, and approvals that were applicable to the original document.

b. Quality standards are specified in the design documents, such as appropriate fire protection codes and standards, and deviations and changes from these quality standards are controlled.

c. New designs and plant modifications, including fire protection systems, are reviewed by qualified personnel to ensure inclusion of appropriate fire protection requirements. These reviews should include items such as:

   - Design reviews to verify adequacy of wiring isolation and cable separation criteria.

   - Design reviews to verify appropriate requirements for room isolation (sealing penetrations, floors, and other fire barriers).

d. A review and approval of the adequacy of fire protection requirements and quality requirements stated in procurement documents are performed and documented by qualified personnel. This review should determine that fire protection requirements and quality requirements are correctly stated, inspectable, and controllable; there are adequate acceptance and rejection criteria; and the procurement document has been prepared, reviewed, and approved in accordance with applicable QA program requirements.

1.7.2 Instructions, Procedures, and Drawings

Inspections, tests, administrative controls, fire drills, and training that govern the fire protection program should be prescribed by documented instructions, procedures, or drawings and should be accomplished in accordance with these documents such that:

a. Indoctrination and training programs for fire prevention and fire fighting are implemented in accordance with documented procedures.

b. Activities such as design, installation, inspection, test, maintenance, and modification of fire protection systems are prescribed and accomplished in accordance with documented instructions, procedures, and drawings.

c. Instructions and procedures for design, installation, inspection, test, maintenance, modification, and administrative controls are reviewed to ensure that the proper fire protection requirements are addressed, such as control of ignition sources and combustibles, provisions for backup fire protection capability, disabling a fire protection system, and the restriction on material substitution unless specifically evaluated.

d. The installation or application of penetration seals, fire barrier systems, and fire retardant coatings is performed by trained personnel using approved procedures.

1.7.3 Control of Purchased Material, Equipment, and Services

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

a. Provisions, as appropriate, for source evaluation and selection, objective evidence of quality furnished by the contractor, inspections at suppliers, or receipt inspections.

b. Source or receipt inspection, as a minimum, for those items whose quality cannot be verified after installation.

1.7.4 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 to documented installation drawings and test procedures for accomplishing activities. This program should include:

a. Inspections of:
   - Installation, maintenance, and modification of fire protection systems or features.
   - Emergency lighting and communication equipment to ensure conformance to design and installation requirements.

b. Inspection of penetration seals, fire barriers, and fire retardant coating installations to verify the activity is satisfactorily completed.

c. Inspections of cable routing to verify conformance with design requirements.

d. Inspections to verify that appropriate requirements for room isolation (sealing penetrations, floors, and other fire barriers) are accomplished during construction.

e. Measures to ensure that inspection personnel are independent from the individuals performing the activity being inspected and are knowledgeable in the design and installation requirements for fire protection.

f. Inspection procedures, instructions, and check lists that provide for:
- Identification of characteristics and activities to be inspected.
- Identification of the individuals or groups responsible for performing the inspection operation.
- Acceptance and rejection criteria.
- A description of the method of inspection.
- Recording evidence of completing and verifying a manufacturing, inspection, or test operation.
- Recording inspector or data recorder and the results of the inspection operation.

g. Periodic inspections of fire protection systems, emergency breathing and auxiliary equipment, emergency lighting, and communication equipment to ensure the acceptable condition of these items.

h. Periodic inspection of materials subject to degradation such as fire barriers, stops, seals, and fire retardant coatings to ensure these items have not deteriorated or been damaged.

1.7.5 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. The test program should include:

a. Installation Testing — Following construction, modification, repair or replacement, sufficient testing should be performed to demonstrate that fire protection systems, emergency lighting, and communication equipment will perform satisfactorily in service and that design criteria are met. Written test procedures for installation tests incorporate the requirements and acceptance limits contained in applicable design documents.

b. Periodic testing — The schedules and methods for periodic testing are developed and documented. Fire protection equipment, emergency lighting, and communication equipment are tested periodically to ensure that the equipment will function properly and continue to meet the design criteria.

c. Programs are established for QA/QC to verify testing of fire protection systems and features and to verify that test personnel are effectively trained.

d. Test results are documented, evaluated, and their acceptability determined by a qualified responsible individual or group.

1.7.6 Inspection, Test, and Operating Status

Measures should be established to provide for the documentation or identification of items that have satisfactorily passed required tests and inspections. These measures should include provisions for identification by means of tags, labels, or similar temporary markings to indicate completion of required inspections and tests and operating status.

1.7.7 Nonconforming Items

Measures should be established to control items that do not conform to specified requirements to prevent inadvertent use or installation. These measures should include provisions to ensure that:

a. Nonconforming, inoperative, or malfunctioning fire protection systems, emergency lighting, and communication equipment are appropriately tagged or labeled.

b. The identification, documentation, segregation, review disposition, and notification to the affected organization of nonconforming materials, parts, components, or services are procedurally controlled.

c. Documentation identifies the nonconforming item, describes the nonconformance and the disposition of the nonconforming item and includes signature approval of the disposition.

d. Provisions are established to identify those individuals or groups delegated the responsibility and authority for the disposition and approval of nonconforming items.

1.7.8 Corrective Action

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

a. Procedures are established for evaluation of conditions adverse to fire protection (such as nonconformance, failures, malfunctions, deficiencies, deviations, and defective material and equipment) to determine the necessary corrective action.

b. In the case of significant or repetitive conditions adverse to fire protection, including fire incidents, the cause of the conditions is determined and analyzed, and prompt corrective actions are taken to preclude recurrence. The cause of the condition and the corrective action taken are promptly reported to cognizant levels of management for review and assessment.

1.7.9 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 such that:

a. Records are identifiable and retrievable and should demonstrate conformance to fire protection requirements. The records should include results of inspections, tests, reviews,

and audits; non-conformance and corrective action reports; construction, maintenance, and modification records; and certified manufacturers' data.

b. Record retention requirements are established.

1.7.10 Audits

Audits should be conducted and documented to verify compliance with the fire protection program such that:

a. Audits are performed to verify compliance with the administrative controls and implementation of quality assurance criteria, including design and procurement documents, instructions, procedures, drawings, and inspection and test activities as they apply to fire protection features and safe shutdown capability. These audits are performed by QA personnel in accordance with preestablished written procedures or check lists and conducted by trained personnel not having direct responsibilities in the areas being audited.

b. Audit results are documented and then reviewed with management that has responsibility in the area audited.

c. Follow-up action is taken by responsible management to correct the deficiencies revealed by the audit.

d. Audits are performed annually to provide an overall assessment of conformance to fire protection requirements.

Fire protection audits should be performed by a qualified audit team. The team should include at least a lead auditor from the licensee's QA organization, a systems engineer, and a fire protection engineer. The lead auditor should be qualified, for example, per ASME NQA-1, “Quality Assurance Program Requirements for Nuclear Facilities” (or alternative consistent with the general quality assurance program requirements). The systems engineer should be knowledgeable in safety systems, operating procedures, and emergency procedures. The fire protection engineers (or engineering consultant) should meet the qualifications for membership in the Society of Fire Protection Engineers at the grade of member. The fire protection engineer can be a licensee employee who is not directly responsible for the site fire protection program for two of three years, but should be an outside independent fire protection consultant every third year. This audit team approach will ensure that the technical requirements as well as the QA requirements are adequately assessed.

Insurance company inspections typically do not satisfy any of the fire protection audit requirements because they do not evaluate plant fire protection programs against NRC requirements, including the requirements for post-fire safe shutdown. Insurance company inspections do not reassess or re-evaluate the fire protection program, since the insurance company has already agreed to insure the licensee's program as it is being implemented. Insurance company inspections are generally limited to checking systems and materials for proper condition and maintenance, and inspecting hazardous conditions related to property protection and life. However, if the insurance company develops an inspection that has the proper scope and the

inspection team includes a person knowledgeable in nuclear safety, an insurance company may perform these audits in conjunction with a lead auditor from the licensee's QA organization.

Three distinct fire protection audits are specified below. Originally, licensees were required to incorporate these audits into their Technical Specifications, consistent with Standardized Technical Specification Section 6.5.2.8, items h, i, and j. Some licensees may have elected to relocate technical specification requirements related to review and audit requirements to the QA plan. Incorporation of such requirements into the QA plan may revise existing technical specification audit frequencies by implementation of a performance-based schedule. Exceptions to the allowable use of performance-based audit frequencies include the triennial audit of fire protection plans, conducted by outside qualified fire consultants, which should be maintained in accordance with technical specification requirements.

1.7.10.1 Annual Fire Protection Audit. For those licensees who have relocated audit requirements from their Technical Specifications to the QA program, "annual" fire protection audits may be changed to a "maximum interval of 24 months" by implementation of a performance-based schedule, if justified by performance reviews, provided that the maximum audit interval does not exceed the 2-year interval specified in ANSI N18.7.

The elements that should be incorporated in the annual audit are:

a. Purpose -- The purpose of the annual audit is to assess the plant fire protection equipment and program implementation to verify that a level of safety consistent with NRC guidelines continues to be provided.

b. Scope -- Each audit should verify that the commitments of the SAR and that the requirements of the Technical Specifications and license conditions have been met and that modifications to systems and structures or changes in operating procedures have not decreased the level of safety in the plant. The audit should include inspection of all plant areas for which fire protection is provided and, in particular, examination of fire barriers, fire detection systems, and fire extinguishing systems provided for equipment important to safety. The audit should verify that:

    i. The installed fire protection systems and barriers are appropriate for the objects protected by comparing them to NRC guidelines and SER-approved alternatives and noting any deviations.

    ii. The fire hazard in each fire area has not increased above that which was specified in the SAR.

    iii. Regularly scheduled maintenance is performed on plant fire protection systems.

    iv. Identified deficiencies have been promptly and adequately corrected.

    v. Special permit procedures (hot work, valve positioning) are being followed.

vi. Plant personnel are receiving appropriate training in fire prevention and firefighting procedures and the training program is consistent with approved standards. (The audit team should witness a typical training session.)

vii. Plant response to fire emergencies is adequate by analyzing incident records and witnessing an unplanned fire drill.

viii. Administrative controls are limiting transient combustibles in areas important to safety.

ix. Problem areas identified in previous audits have been corrected.

The audit should analyze all problem areas identified by the audit and recommend appropriate fire protection measures to provide a level of safety consistent with NRC guidelines.

1.7.10.2 24-Month Fire Protection Audit. The purpose of the 24-month audit of the fire protection program and implementing procedures is to ensure that the requirements for design, procurement, fabrication, installation, testing, maintenance, and administrative controls for the respective programs continue to be included in the plant QA program for fire protection and meet the criteria of the QA/QC program established by the licensee, consistent with this guide. These audits should be performed by personnel from the licensee's QA organization who do not have direct responsibility for the program being audited. These audits would normally encompass an evaluation of existing programmatic documents to verify continued adherence to NRC requirements.

1.7.10.3 Triennial Fire Protection Audit. The triennial audit is basically the same as the annual audit; the difference lies in the source of the auditors. The annual audit may be performed by qualified utility personnel who are not directly responsible for the site fire protection program or by an outside independent fire protection consultant. The triennial audit should be performed by an outside independent fire protection consultant. These audits would normally encompass an evaluation of existing documents (other than those addressed under the 24-month audit) plus an inspection of fire protection system operability, inspection of the integrity of fire barriers, and witnessing the performance of procedures to verify that the fire protection program has been fully implemented and is adequate for the objects protected. Duplicate audits are not required, i.e., the 3-year audit replaces the "annual audit" the year it is performed.

The guidance in Regulatory Position 1.7 is based on CMEB 9.5-1, AL 95-06. GL 82-21, and GL 86-10.

1.8 Fire Protection Program Changes/Code Deviations

This section provides guidance relative to the regulatory mechanisms for addressing changes, deviations, exemptions, and other issues affecting compliance with fire protection regulatory requirements.

1.8.1 Safety Evaluations

If the licensee has adopted the standard license condition and incorporated the fire protection program in the FSAR, the licensee may make changes to the approved fire protection program without prior approval of the Commission only if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire as documented in a safety evaluation. In addition to planned changes, a safety evaluation may also be required for nonconforming conditions.

Generic Letter 86-10 recommended that licensees incorporate the fire protection program in the facility Final Safety Analysis Report (FSAR). Incorporation of the fire protection program and major commitments, including the fire hazards analysis, by reference into the FSAR for the facility places the fire protection program, including the systems, the administrative and technical controls, the organization, and other plant features associated with fire protection on a consistent status with other plant features described in the FSAR. Generic Letter 86-10 further recommended the adoption of the standard license condition (see Regulatory Position 1.8.1.2), requiring licensees to comply with the provisions of the approved fire protection program as described in the FSAR and establishing when NRC approval for changes to the program is required.

The licensee should maintain, in auditable form, a current record of all such changes, including an analysis of the effects of the change on the fire protection program, and should make such records available to NRC Inspectors upon request. All changes to the approved program should be reported, along with the FSAR revisions required by 10 CFR 50.71(e).

1.8.1.1 Non-Standard License Condition. If the fire protection program committed to by the licensee is required by a specific license condition and is not part of the FSAR for the facility, licensees may be required to submit amendment requests even for relatively minor changes to the fire protection program.

1.8.1.2 Standard License Condition. The standard license condition for fire protection was transmitted to licensees in April 1986 as part of Generic Letter 86-10 with information on its applicability to specific plants. The standard license condition reads as follows:

> <u>Fire Protection</u>
>
> (Name of Licensee) shall implement and maintain in effect all provisions of the approved fire protection program as described in the Final Safety Analysis Report for the facility (or as described in submittals dated ----------) and as approved in the SER dated -----------(and Supplements dated ---------) subject to the following provision:
>
> The licensee may make changes to the approved fire protection program without prior approval of the Commission only if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire.

The adoption of the standard license condition in conjunction with the incorporation of the fire protection program in the FSAR for the facility provides a more consistent approach to evaluating changes to the facility, including those associated with the fire protection program.

Within the context of the standard fire protection license condition, the phrase "not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire," means to maintain sufficient safety margins. See Regulatory Guide 1.174 for additional information.

1.8.1.3 Exemption/Deviation vs Standard License Condition. If a proposed change involves a change to a license condition or technical specification that was used to satisfy NRC requirements, a license amendment request should be submitted. When a change that falls within the scope of the changes allowed under the standard fire protection license condition is planned, the evaluation is made in conformance with the standard fire protection license condition to determine whether the change would adversely affect the ability to achieve and maintain safe shutdown. The assessment should include the effect on the fire hazard analysis and the consideration of whether circuits or components, including associated circuits, for a success path of equipment needed for safe shutdown are being affected or a new element introduced in the area. If this evaluation concludes that there is no adverse affect, this conclusion and its basis should be documented and be available for future inspection and reference. If the evaluation finds that there is an adverse affect, or that it is outside the basis for an exemption (or deviation) that was granted (or approved) for the area involved, the licensee should make modifications to achieve conformance, justify and request an exemption, or seek a license amendment from the NRC.

1.8.1.4 Nonconforming Conditions. In addition to evaluation of planned changes, a safety evaluation may also be required for nonconforming conditions.

In the case of a degraded or nonconforming condition, a safety evaluation is dependent on the compensatory and corrective actions taken by the licensee. There are three potential conditions for determining the need for performance of a safety evaluation. These conditions are the use of interim compensatory actions, or corrective actions that result in a change, or corrective actions that restore the nonconforming or degraded condition to the previous condition.

If an interim compensatory action is taken to address the condition that falls within the scope of the standard fire protection license condition, a review should be conducted and may result in a safety evaluation. The intent is to determine whether the compensatory action itself (not the degraded condition) impacts other aspects of the facility described in the FSAR.

In its evaluation of the impact of a degraded or nonconforming condition on plant operation and on operability of structures, systems, and components, a licensee may decide to implement a compensatory measure as an interim step to restore operability or to otherwise enhance the capability of structures, systems, and components until the final corrective action is complete. Reliance on a compensatory measure for operability should be an important consideration in establishing the "reasonable time frame" to complete the corrective action process. In accordance with GL 91-18, NRC would normally expect that conditions that require interim compensatory measures to demonstrate operability would be resolved more promptly than conditions that are not dependent on compensatory measures to show operability, because such reliance suggests a greater degree of degradation. Similarly, if an operability determination is based upon operator action, NRC would expect the nonconforming condition to be resolved expeditiously.

If the condition is accepted "as-is," resulting in something different from that described in the FSAR or is modified to something different from that described in the FSAR, the condition should be considered a change and subjected to a safety evaluation.

1.8.1.5 Reporting Guidelines. The licensee should maintain records of fire protection program-related changes in the facility, of changes in procedures, and of tests and experiments made in accordance with the standard fire protection license condition. These records should include a written evaluation that provides the bases for the determination that the change does not adversely affect safe shutdown capability.

In accordance with 10 CFR 50.48, the records of changes in the facility must be maintained until the termination of the license. Records of superseded procedures must be maintained for a period of 3 years from the date the record was superseded.

The guidance in Regulatory Position 1.8.1 is based on 10 CFR 50.48, GL 86-10, and GL 91-18.

1.8.2 Exemptions to Appendix R of 10 CFR Part 50

For plants licensed prior to January 1, 1979, exemption requests from the requirements of Appendix R are required for modifications or conditions that do not comply with the applicable sections of Appendix R. The exclusion of the applicability of sections of Appendix R other than III.G (and III.L as applicable), III.J, and III.O is limited to those features accepted by the NRC staff as satisfying the provisions of Appendix A to Branch Technical Position APCSB 9.5-1 reflected in staff fire protection safety evaluation reports issued prior to the effective date of the rule. For these previously approved features, an exemption request is not required except for proposed modifications that would alter previously approved features used to satisfy NRC requirements.

Plant-specific conditions may preclude compliance with one or more of the provisions specified in Appendix R. In such a case, the licensee should demonstrate, by means of a detailed fire hazards analysis, that the existing protection, or that the existing protection in conjunction with proposed modifications, will provide a level of safety equivalent to the technical requirements of Appendix R.

When the fire hazards analysis (see Regulatory Position 1.2 of this guide) shows that adequate fire safety can be provided by an alternative approach (i.e., an approach different from the specified requirement such as the use of a 1-hour fire rated barrier where a 3-hour barrier is specified), licensees that are required to meet Appendix R may request NRC approval of an exemption from the technical requirements of Appendix R. Any exemption request should include a sound technical basis that clearly demonstrates that the fire protection defense-in-depth philosophy is appropriately maintained and that the exemption is technically justified. As part of its evaluation, the licensee should provide sound technical justification if it does not propose to install or improve the automatic suppression and/or detection capabilities in the area of concern, and/or to implement other more restrictive fire prevention, detection, or suppression measures.

Generally, the staff will accept an alternative fire protection configuration on the basis of a detailed fire hazards analysis if:

a. The alternative ensures that one success path of equipment necessary to achieve hot shutdown from either the control room or emergency control stations is free of fire damage; and

b. The alternative ensures that fire damage to equipment necessary to achieve cold shutdown is limited so that it can be repaired within a reasonable time (minor repair using components stored on the site); and

c. Fire-retardant coatings are not used as fire barriers; and

d. Modification required to meet Appendix R would not enhance fire protection safety levels above that provided by either existing or proposed alternatives.

The staff will also accept an alternative fire protection configuration on the basis of a detailed fire hazards analysis when the licensee can demonstrate that modifications required to meet Appendix R would be detrimental to overall facility safety, the alternative configuration satisfies the four aforementioned criteria, and the alternative configuration provides an adequate level of fire safety.

Exemptions to the requirements of 10 CFR 50.48 and Appendix R are to be filed in accordance with 10 CFR 50.12.

The guidance in Regulatory Position 1.8.2 is based on GL 86-10.

1.8.3 Appendix R Equivalency Evaluations

NRC interpretations of certain Appendix R requirements allow a licensee to choose not to seek prior NRC review and approval of, for example, a fire area boundary, in which case an evaluation should be performed by a fire protection engineer (assisted by others as needed) and retained for future NRC audit. Evaluations of this type should be written and organized to facilitate review by a person not involved in the evaluation. All calculations supporting the evaluation should be available and all assumptions clearly stated at the outset. The evaluations should be retained for subsequent NRC audits. Appendix A to this guide provides examples.

The guidance in Regulatory Position 1.8.3 is based on GL 86-10.

1.8.4 Deviations

Plants licensed after January 1, 1979, that have committed to meet the requirements of Sections III.G, III.J, and III.O of Appendix R or other NRC guidance (e.g., CMEB 9.5-1), and are required to do so as a license condition, do not need to request exemptions for alternative configurations. However, deviations from the requirements of Sections III.G, III.J, and III.O or other applicable requirements or guidance should be identified and justified in the FSAR or FHA and the deviation may require a license amendment to change the license condition. Deviations submitted to the NRC for review and approval should include a technical justification for the proposed alternative approach. The technical justification should address the criteria described in Regulatory Positions 1.8.1, Safety Evaluations, and 1.8.2 for exemptions.

The guidance in Regulatory Position 1.8.4 is based on GL 86-10.

1.8.5 Operability Assessments

Structures, systems, and components that are relied upon in the licensee's fire protection plan required under 10 CFR 50.48 are to be subjected to operability assessments and prompt corrective action when inoperable, degraded, or nonconforming conditions are identified. The process of ensuring operability is continuous and consists of the verification of operability by surveillance activities and formal determinations of operability whenever a verification or other indication calls into question the ability of a structure, system, or component to perform its specified function. Prompt action should be taken by the licensee any time a structure, system, or component important to safety is found to be inoperable. If an immediate threat to public health and safety is identified, action to place the plant in a safe condition should begin as soon as possible.

A structure, system, or component is considered operable when it can perform its intended function (e.g., a fire pump that is rated for 2500 GPM at 120 psi is capable of meeting or exceeding that flow and pressure). The definition of operability includes the principle that a system can perform its specified safety functions only when all its necessary support systems are capable of performing their related support functions (e.g., an automatic fire suppression system is operable only if the detection system that is used to actuate the fire suppression system is also operable). If a necessary support system is inoperable, the corresponding structure, system, or component should also be declared inoperable. The operability determination may be based on analysis, testing, operating experience, engineering judgment, or a combination of these methods. In the absence of a reasonable expectation that a structure, system, or component is operable, the structure, system, or component should be declared inoperable.

Full qualification of a required structure, system, or component is defined as conforming to all aspects of the current licensing basis, including the applicable codes and standards (e.g., NFPA), design criteria, and commitments (e.g., Branch Technical Positions). The fact that a structure, system, or component is not fully qualified may render the structure, system, or component degraded or nonconforming, but does not in all cases render that structure, system, or component unable to perform its specified function. A degraded condition exists when there has been an loss of quality or functional capability of a structure, system or component (e.g., a fire barrier that was credited with a fire resistance rating of 3 hours has been determined by a fire test to provide a fire resistance rating of only two hours). A nonconforming condition exists when there is a failure to meet requirements or licensee commitments (e.g., missing the performance of the weekly fire pump test as required by NFPA 20). If a structure, system, or component important to safety is degraded or nonconforming but operable, the licensee should establish an acceptable basis for its continued operability. The licensee should promptly identify and correct the condition that resulted in the degraded or nonconforming condition.

Automatic actuation of structures, systems, or components is frequently provided as a design feature for mitigating fire events (e.g., automatic suppression systems). When the licensee is considering the substitution of a manual action for an automatic actuation, the licensee's determination of operability should consider the differences in the performance between the automatic and manual action and the ability of the manual action to accomplish the specified

function. The licensee should have written procedures in place and training prior to the substitution of any manual action for the loss of an automatic feature.

Compensatory measures may be used as an interim step to restore operability or to enhance the capability of structures, systems, or components that are degraded or nonconforming until the final corrective action is completed. Reliance on compensatory measures should be considered in establishing the reasonable time frame to complete the corrective action process. Generally, conditions that require compensatory measures to restore or enhance operability should be resolved more promptly than conditions that are not dependent upon compensatory measures. The compensatory measures selected should be appropriate to the adverse condition identified (e.g., use of mobile fire apparatus to compensate for a fire pump that is degraded). See Regulatory Position 1.5 for additional guidance regarding compensatory actions.

The guidance in Regulatory Position 1.8.5 is based on GL 91-18 and IM STS-10.

1.8.6 10 CFR 50.72 Notification and 10 CFR 50.73 Reporting

The requirements of 10 CFR 50.72 and 10 CFR 50.73 have applicability to reporting certain events and conditions related to fire protection at nuclear power plants. Fire events or fire protection deficiencies that meet the criteria of 10 CFR 50.72 and 50.73 should be reported to the NRC as appropriate, and in accordance with the requirements of these regulations. Guidance for meeting the requirements of 10 CFR 50.72 and 50.73 is provided in NUREG-1022, "Event Reporting Guidelines: 10 CFR 50.72 and 50.73," which was prepared by the NRC staff to clarify implementation of the 10 CFR 50.72 and 50.73 rules and consolidate important NRC reporting guidelines into one reference document. The document is structured to assist licensees in achieving prompt and complete reporting of specified events and conditions.

Additional reporting guidance for 10 CFR 50.72 and 50.73 was contained in the Statements of Considerations for the rules.

The guidance in Regulatory Position 1.8.6 is based on 10 CFR 50.72, 10 CFR 50.73, and NUREG-1022.

1.8.7 NFPA Code and Standard Deviation Evaluations

For those fire protection structures, systems, and components installed to satisfy NRC requirements designed to NFPA codes and standards, the code edition in force at the time of the design and installation is the code of record to which the design is evaluated. Deviations from the codes should be identified and justified in the FSAR or FHA. Deviations should not degrade the performance of fire protection systems or features. The code of record is determined by the licensee.

A licensee may apply the equivalency concept in meeting the provisions of the NFPA codes and standards. Nothing in the NFPA codes or standards is intended to prevent the use of methods, systems, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety as alternatives to those prescribed by the codes or standards, provided technical documentation demonstrates equivalency and the method, system, or device is listed or approved for the intended purpose.

An exemption is not required for deviation from NFPA codes. NRC guidelines reference certain NFPA codes as providing guidance acceptable to the staff, and therefore such codes may be accorded the same status as regulatory guides.

When the applicant/licensee states that its design "meets the NFPA code(s)" or "meets the intent of the NFPA code(s)" and does not identify any deviations from such codes, the NRC expects that the design conforms to the codes and the design is subject to inspection against the NFPA codes.

The “Authority Having Jurisdiction” as described in NFPA documents refers to the Director, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, or designee, consistent with the authority specified in 10 CFR 1.43.

The guidance in Regulatory Position 1.8.7 is based on GL 86-10.

2. FIRE PREVENTION

Administrative controls and procedures should be established to minimize fire hazards in areas containing structures, systems, and components important to safety. 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 hazard conditions such as those associated with maintenance activities should be reviewed by appropriate levels of management, and appropriate compensatory measures such as fire watches or temporary fire barriers should be implemented to ensure adequate fire protection and reactor safety.

The following sections provide guidance relative to fire prevention measures, including control of combustibles and ignition sources, and housekeeping inspections. Organizational responsibilities for implementation of fire prevention measures are discussed in Regulatory Position 1.1. Portions of NFPA 1, "Fire Prevention Code," including Chapters 3-8, 28, and 34, contain additional guidance that may be used in the development and implementation of fire prevention measures.

2.1 Control of Combustibles

Fire prevention administrative controls should include procedures to control handling and use of combustibles, prohibit storage of combustibles in plant areas important to safety or establish designated storage areas with appropriate fire protection, and control use of specific combustibles (e.g., wood) in plant areas important to safety.

2.1.1 Transient Fire Hazards

Bulk storage of combustible materials should be prohibited inside or adjacent to buildings or systems important to safety during all modes of plant operation. Procedures should govern the handling of and limit transient fire hazards such as combustible and flammable liquids, wood and plastic products, high-efficiency particulate air and charcoal filters, dry ion exchange resins, or other combustible materials in buildings containing systems or equipment important to safety

during all phases of operation, and especially during maintenance, modification, or refueling operations.

Transient fire hazards that cannot be eliminated should be controlled and suitable protection should be provided. Specific controls and protective measures include:

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

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

- Use of wood inside buildings containing systems or equipment important to safety should be permitted only when suitable noncombustible substitutes are not available. All wood smaller than 152 mm x 152 mm (6 inch x 6 inch) used in plant areas important to safety during maintenance, modification, or refueling operation (such as lay-down blocks or scaffolding) should be treated with a flame retardant (see NFPA 703, "Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials," for guidance). Wood should be allowed into plant areas important to safety only when it is to be used immediately.

- The use of plastic materials should be minimized. Halogenated plastics such as polyvinyl chloride (PVC) and neoprene should be used only when substitute noncombustible materials are not available. All plastic materials, including flame and fire retardant materials, will burn with an intensity and BTU production in a range similar to that of ordinary hydrocarbons. When burning, they produce heavy smoke that obscures visibility and can plug air filters, especially charcoal and HEPA filters. The halogenated plastics also release free chlorine and hydrogen chloride when burning, which are toxic to humans and corrosive to equipment. NFPA 701, "Standard Methods of Fire Tests for Flame-Resistant Textiles and Films," provides guidance on fire testing of flame resistant plastic films (e.g., plastic sheeting, tarpaulins).

- Use of combustible material such as HEPA and charcoal filters, dry ion exchange resins, or other combustible supplies in areas important to safety should be controlled. Such materials should be allowed into areas important to safety only when they are to be used immediately.

- Equipment or supplies (such as new fuel) shipped in untreated combustible packing containers may be unpacked in areas containing equipment or systems important to safety if required for valid operating reasons. However, all combustible materials should be removed from the area immediately following unpacking. Such transient combustible material, unless stored in approved containers, should not be left unattended. Loose combustible packing material, such as wood or paper excelsior or polyethylene sheeting, should be placed in metal containers with tight-fitting self-closing metal covers.

- 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.

2.1.2 Modifications

The guidelines of Regulatory Position 4.1.1 should be followed in the design of plant modifications. Modifications of structures, systems, and components should be reviewed by personnel in the fire protection organization to ensure that fixed fire loadings are not increased beyond those accounted for in the fire hazards analysis, or if increased, suitable protection is provided and the fire hazards analysis is revised accordingly.

2.1.3 Flammable and Combustible Liquids and Gases

The handling, use, and storage of flammable and combustible liquids should, as a minimum, comply with the provisions of NFPA 30, "Flammable and Combustible Liquids Code."

Miscellaneous storage and piping for flammable or combustible liquids or gases should not create a potential fire exposure hazard to systems important to safety.

Systems important to safety should be isolated or separated from combustible materials. When this is not possible because of the nature of the safety system or the combustible material, special protection should be provided to prevent a fire from defeating the safety system function. Such protection may involve a combination of automatic fire suppression and construction capable of withstanding and containing a fire that consumes all combustibles present. Examples of such combustible materials that may not be separable from the remainder of its system are emergency diesel generator fuel oil day tanks, turbine-generator oil and hydraulic control fluid systems, and reactor coolant pump lube oil systems.

Diesel fuel oil tanks should meet the guidelines of Regulatory Positions 6.1.8 and 7.4 of this guide. Turbine-generator lube oil and hydraulic systems should meet the guidelines in Regulatory Position 7.2. Reactor coolant pump oil collection system guidelines are provided in Regulatory Position 7.1.

Bulk gas storage and use should meet the guidelines of Regulatory Position 7.5 of this guide.

2.1.4 External/Exposure Fire Hazards

When a structure, system or component important to safety is near installations, such as flammable liquid or gas storage, the risk of exposure fires (originating in such installations) to the structures, systems, and components should be evaluated and appropriate protective measures taken. NFPA 80A, "Recommended Practice for Protection of Buildings from Exterior Fire Exposures," provides guidance on such exposure protection. NFPA 30 provides guidance relative to minimum separation distances from flammable and combustible liquid storage tanks. NFPA 50A, “Standard for Gaseous Hydrogen Systems at Consumer Sites,” and NFPA 50B, “Standard for Liquefied Hydrogen Systems at Consumer Sites,” provide separation distances for gaseous and

liquefied hydrogen, respectively (see Regulatory Position 7.5). NFPA 58, “Liquefied Petroleum Gas Code,” provides guidance for liquefied petroleum gas.

Miscellaneous areas such as shops, warehouses, auxiliary boiler rooms, fuel oil tanks, and flammable and combustible liquid storage tanks should be located and protected such that a fire or effects of a fire, including smoke, will not adversely affect any systems or equipment important to safety. See the previous section for guidelines relative to location of diesel fuel oil tanks and compressed gas supplies external to structures important to safety.

In geographic areas where there is a potential for damage from wildfires (i.e., forest, brush, vegetation), the risk potential from wildfire should be evaluated for structures that contain systems or components important to safety, and appropriate measures should be taken. NFPA 299, “Standard for Protection of Life and Property from Wildfire,” provides guidance on assessing wildfire severity and appropriate protection measures.

The guidance in Regulatory Position 2.1 is based on Appendix R to 10 CFR Part 50 and CMEB 9.5-1.

2.2 Control of Ignition Sources

Fire protection administrative controls should establish procedures to govern use of ignition sources.

2.2.1 Open Flame, Welding, Cutting and Grinding (Hot Work)

Work involving ignition sources such as welding and flame cutting should be done under closely controlled conditions. Persons performing and directly assisting in such work should be trained and equipped to prevent and combat fires. If this is not possible, a person qualified in fire protection should directly monitor the work and function as a fire watch.

The use of ignition sources should be governed by use of a hot work permit system to control open flame, welding, cutting, brazing, or soldering operations. A separate permit should be issued for each area where work is to be done. If work continues over more than one shift, the permit should be valid for not more than 24 hours when the plant is operating or for the duration of a particular job during plant shutdown. NFPA-51B, "Standard for Fire Prevention in Use of Cutting and Welding Processes," includes guidance for safeguarding the hazards associated with welding and cutting operations.

2.2.2 Temporary Electrical Installations

The use of temporary services at power reactor facilities is routine, especially in support of maintenance and other activities during outages. In view of the magnitude and complexity of some temporary services, proper engineering and, once installed, maintenance of the design basis become significant. Plant administrative controls should provide for engineering review of temporary installations. These reviews should ensure that appropriate precautions, limitations, and maintenance practices are established for the term of such installations. The Institute of Electrical and Electronic Engineers (IEEE) Standard 835, "Standard Power Cable Ampacity Tables,"

ANSI/IEEE C.2, “National Electrical Safety Code,®” and NFPA 70, "National Electrical Code," provide guidance on temporary electrical installations, including derating of closely spaced cables.

2.2.3 Other Sources

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

Temporary heating devices should be placed so as to avoid overturning and installed in accordance with their listing, including clearance to combustible material, equipment, or construction. Asphalt and tar kettles should be located in a safe place or on a fire-resistive roof at a point where they avoid ignition of combustible material below. Continuous supervision should be maintained while kettles are in operation and metal kettle covers and fire extinguishers should be provided.

The guidance in Regulatory Position 2.2 is based on ASB 9.5-1, CMEB 9.5-1, IN 91-17, and IP 64704.

2.3 Housekeeping

Administrative controls should be established to minimize fire hazards in areas containing structures, systems, and components important to safety. These controls should establish procedures to govern removal of waste, debris, scrap, oil spills, and other combustibles after completion of a work activity or at the end of the shift and to maintain housekeeping inspections. Periodic housekeeping inspections should be performed to ensure continued compliance with fire protection administrative controls. Regulatory Guide 1.39 provides guidance on housekeeping, including the disposal of combustible materials.

The guidance in Regulatory Position 2.3 is based on Appendix R to 10 CFR Part 50, CMEB 9.5-1, and Regulatory Guide 1.39.

2.4 Fire Protection System Maintenance and Impairments

Fire protection administrative controls should be established to address the following:

a. Fire protection features should be maintained and tested by qualified personnel (see Regulatory Position 1.6.1.c).

b. Impairments to fire barriers, fire detection, and fire suppression systems should be controlled by a permit system. Compensatory measures (see Regulatory Position 1.5) should be established in areas where systems are so disarmed.

c. Successful fire protection requires inspection, testing, and maintenance of the fire protection equipment. A test plan that lists the individuals and their responsibilities in connection with routine tests and inspections of the fire protection systems should be developed. The test plan should contain the types, frequency, and detailed procedures for

testing. Frequency of testing should be based on the code of record for the applicable fire protection system. 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.

d. Fire barriers, including dampers, doors, and penetration seals, should be routinely inspected. Penetration seals may be inspected on a frequency and relative sample basis that provides assurance that the seals are functional. Sample size and inspection frequency should be determined by the total number of penetrations and observed failure rates. Inspection frequency should ensure that all seals will be inspected every 10 years.

The guidance in Regulatory Position 2.4 is based on Appendix R to 10 CFR Part 50 and CMEB 9.5-1.

3. FIRE DETECTION AND SUPPRESSION

3.1 Fire Detection (Design Objectives and Performance Criteria)

Fire detection systems should be designed to minimize the adverse effects of fires on structures, systems, and components important to safety. Automatic fire detection systems should be installed in all areas of the plant that contain or present an exposure fire hazard to structures, systems, and components important to safety. These fire detection systems should be capable of operating with or without offsite power.

With regard to protection of safe shutdown systems, Regulatory Positions 5.5.b and 5.5.c of this guide state that "In addition, fire detectors and an automatic fire suppression system should be installed in the fire area." See Regulatory Position 1.8.3 and the information in Appendix A for guidance relative to those areas where less than full-area coverage is provided.

3.1.1 Fire Detection and Alarm Design Objectives and Performance Criteria

The fire detection and alarm system should be designed with the following objectives.

a. Detection systems are to be provided for all areas that contain or present a fire exposure to equipment important to safety.

b. Fire detection and alarm systems comply with the requirements of Class A systems as defined in NFPA 72, "National Fire Alarm Code," and Class I circuits as defined in NFPA 70.

c. Fire detectors are selected and installed in accordance with NFPA 72. Pre-operational and periodic testing of pulsed line-type heat detectors demonstrate that the frequencies used will not affect the actuation of protective relays in other plant systems.

d. Fire detection and alarm systems give audible and visible alarm and annunciation in the control room. Where zoned detection systems are used in a given fire area, local means are provided to identify which detector zone has actuated.

e. Fire alarms are distinctive and unique so they will not be confused with any other plant system alarms.

f. Primary and secondary power supplies are provided for the fire detection system and for electrically operated control valves for automatic suppression systems. Such primary and secondary power supplies are to satisfy provisions of NFPA 72. This can be accomplished by using normal offsite power as the primary supply with a 4-hour battery supply as secondary supply and by providing capability for manual connection to the Class 1E emergency power bus within 4 hours of loss of offsite power. Such connection should follow the applicable guidance in Regulatory Guides 1.6, 1.32, and 1.75.

g. In areas of high seismic activity, the need to design the fire detection and alarm systems to be functional following the safe shutdown earthquake should be considered.

h. The fire detection and alarm systems should retain their original design capability for (1) 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 (2) potential man-made site-related events such as oil barge collisions or aircraft crashes that have a reasonable probability of occurring at a specific plant site.

i. Redundant cable systems important to safety located in cable trays should be provided with fire detection. (Also see Regulatory Positions 4.1.3.3 and 6.1.3.)

j. Containment fire detection systems should be provided for non-inerted containments in accordance with the guidance in Regulatory Position 6.1.1.3.

k. Control room fire detection and alarms should be provided in accordance with the guidance in Regulatory Position 6.1.2.

l. The following areas that contain equipment important to safety should be provided with automatic fire detectors that alarm and annunciate in the control room: plant computer rooms, switchgear rooms, remote shutdown panels, battery rooms, diesel generator areas, pump rooms, new and spent fuel areas, and radwaste and decontamination areas. (Also see Regulatory Positions 6.1 and 6.2.)

The guidance in Regulatory Position 3.1 is based on GDC 3, Appendix R to 10 CFR Part 50, and CMEB 9.5-1.

3.2 Fire Protection Water Supply Systems (Design Objectives and Performance Criteria)

3.2.1 Fire Protection Water Supply

NFPA 22, "Standard for Water Tanks for Private Fire Protection," and NFPA 24, "Standard for the Installation of Private Fire Service Mains and Their Appurtenances," provide guidance for fire protection water supplies. The fire protection water supply system should meet the following criteria.

a. Two separate, reliable freshwater supplies should be provided. Saltwater or brackish water should not be used unless all freshwater supplies have been exhausted.

b. The fire water supply should be calculated on the basis of the largest expected flow rate for a period of 2 hours, but not less than 1,136,000 L (300,000 gallons). This flow rate should be based (conservatively) on 1900 L/m (500 gpm) for manual hose streams plus the largest design demand of any sprinkler or deluge system as determined in accordance with NFPA 13, "Standard for the Installation of Sprinkler Systems," or NFPA 15, "Standard for Water Spray Fixed Systems for Fire Protection." The fire water supply should be capable of delivering this design demand over the longest piping route of the water supply system.

c. If tanks are used for water supply, two 100% system capacity tanks [minimum of 1,136,000 L (300,000 gallons) each] should be installed. They should be so interconnected that pumps can take suction from either or both. However, a failure in one tank or its piping should not cause both tanks to drain. Water supply capacity should be capable of refilling either tank in 8 hours or less.

d. Common water supply tanks are acceptable for fire and sanitary or service water storage. When this is done, however, minimum fire water storage requirements should be dedicated by passive means, for example, use of a vertical standpipe for other water services. Administrative controls, including locks for tank outlet valves, are unacceptable as the only means to ensure minimum water volume.

e. Freshwater lakes or ponds of sufficient size may qualify as the sole source of water for fire protection but require separate redundant suctions in one or more intake structures. These supplies should be separated so that a failure of one supply will not result in a failure of the other supply.

f. When a common water supply is permitted for fire protection and the ultimate heat sink, the following conditions should also be satisfied:

    i. The additional fire protection water requirements are designed into the total storage capacity, and

    ii. Failure of the fire protection system should not degrade the function of the ultimate heat sink.

g. Other water systems that may be used as one of the two fire water supplies should be permanently connected to the fire main system and should be capable of automatic alignment to the fire main system. Pumps, controls, and power supplies in these systems should satisfy the requirements for the main fire pumps. The use of other water systems for fire protection should not be incompatible with their functions required for safe plant shutdown. Failure of the other system should not degrade the fire main system.

h. For multi-unit nuclear power plant sites with a common yard fire main loop, common water supplies may be utilized.

i. Fire water supplies should be filtered and treated as necessary to prevent or control biofouling or microbiologically induced corrosion of fire water systems. If the supply is raw service water, fire water piping runs should be periodically flushed and flow tested.

j. Provisions should be made to supply water to at least two standpipes and hose connections for manual firefighting in areas containing equipment required for safe plant shutdown in the event of a safe shutdown earthquake. The piping system serving such hose stations should be analyzed for safe shutdown earthquake loading and should be provided with supports to ensure system pressure integrity. The piping and valves for the portion of hose standpipe system affected by this functional requirement should, as a minimum, satisfy ASME/ANSI B31.1. The water supply for this condition may be obtained by manual operator actuation of valves in a connection to the hose standpipe header from a normal seismic Category I water system such as the essential service water system. The cross connection should be (a) capable of providing flow to at least two hose stations [approximately 284 L/m (75 gpm) per hose station], and (b) designed to the same standards as the seismic Category I water system; it should not degrade the performance of the seismic Category I water system.

3.2.2 Fire Pumps

Fire pump installations should conform to NFPA 20, "Standard for the Installation of Centrifugal Fire Pumps," and should meet the following criteria.

a. If fire pumps are required to meet system pressure or flow requirements, a sufficient number of pumps is provided to ensure that 100% capacity will be available assuming failure of the largest pump or loss of offsite power (e.g., three 50% pumps or two 100% pumps). This can be accomplished, for example, by providing either electric motor-driven fire pumps and diesel-driven fire pumps or two or more seismic Category I Class 1E electric motor-driven fire pumps connected to redundant Class 1E emergency power buses (see Regulatory Guides 1.6, 1.32, and 1.75.)

b. Individual fire pump connections to the yard fire main loop are separated with sectionalizing valves between connections. Each pump and its driver and controls are located in a room separated from the remaining fire pumps by a fire wall with a minimum rating of 3 hours.

c. The fuel for the diesel fire pumps is separated so that it does not provide a fire source exposing equipment important to safety.

d. Alarms or annunciators to indicate pump running, driver availability, failure to start, and low fire-main pressure are provided in the control room.

3.2.3 Fire Mains

An underground yard fire main loop should be installed to furnish anticipated water requirements. NFPA 24 provides appropriate guidance for such installation. NFPA 24 references other design codes and standards developed by such organizations as the American National Standards Institute (ANSI) and the American Water Works Association (AWWA). The following specific criteria should be addressed:

a. Type of pipe and water treatment are design considerations with tuberculation as one of the parameters.

b. Means for inspecting and flushing the fire main are provided.

c. Sectional control valves should be visually indicating, e.g., post-indicator valves.

d. Control and sectionalizing valves in fire mains and water-based fire suppression systems are electrically supervised or administratively controlled (e.g., locked valves with key control, tamper-proof seals). The electrical supervision signal indicates in the control room. All valves in the fire protection system are periodically checked to verify position (see NFPA 25, "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems," for guidance).

e. The fire main system piping is separate from service or sanitary water system piping, except as described in Regulatory Position 3.2.1 with regard to providing seismically designed water supply for standpipes and hose connections.

f. A common yard fire main loop may serve multi-unit nuclear power plant sites if cross-connected between units. Sectional control valves permit maintaining independence of the individual loop around each unit. For multiple-reactor sites with widely separated plants [approaching 1.6 km (1 mile) or more], separate yard fire main loops are used.

g. Sectional control valves are provided to isolate portions of the fire main for maintenance or repair without shutting off the supply to primary and backup fire suppression systems serving areas that contain or expose equipment important to safety.

h. Valves are installed to permit isolation of outside hydrants from the fire main for maintenance or repair without interrupting the water supply to automatic or manual fire suppression systems in any area containing or presenting a fire hazard to equipment important to safety.

i. Sprinkler systems and manual hose station standpipes have connections to the yard main system so that a single active failure or a line break cannot impair both the primary and backup fire suppression systems. Alternatively, headers fed from each end are permitted inside buildings to supply both sprinkler and standpipe systems, provided steel piping and fittings meeting the requirements of ASME/ANSI B31.1 are used for the headers up to and including the first valve supplying the sprinkler systems where such headers are part of the seismically analyzed hose standpipe system. When provided, such headers are considered an extension of the yard main system. Each sprinkler and standpipe system should be equipped with OS&Y (outside screw and yoke) gate valve or other approved shutoff valve and water flow alarm.

The guidance in Regulatory Position 3.2 is based on Appendix R to 10 CFR Part 50, CMEB 9.5-1, Supplement 1 to GL 89-13, and IE Bulletin BL 81-03.

3.3 Automatic Suppression Systems (Design Objectives and Performance Criteria)

Automatic suppression should be installed as determined by the fire hazards analysis and as necessary to protect redundant systems or components necessary for safe shutdown (see Regulatory Positions 5.5.b, 5.5.c, and 1.3.1).

In areas of high seismic activity, the need to design the fire suppression systems to be functional following the safe shutdown earthquake should be considered.

The fire suppression systems should retain their original design capability for (1) 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 (2) potential man-made site-related events such as oil barge collisions or aircraft crashes that have a reasonable probability of occurring at a specific plant site.

3.3.1 Water-based Systems

Equipment important to safety that does not itself require protection by water-based suppression systems but is subject to unacceptable damage if wetted by suppression system discharge should be appropriately protected (e.g., water shields or baffles).

3.3.1.1 Sprinkler and Spray Systems. Water sprinkler and spray suppression systems are the most widely used means of implementing automatic water-based fire suppression. Sprinkler and spray systems should, as a minimum, conform to requirements of appropriate standards such as NFPA 13 and NFPA15.

3.3.1.2 Water Mist Systems. Water mist suppression systems may be useful in specialized situations, particularly where the application of water needs to be restricted. Water mist systems should conform to appropriate standards such as NFPA 750, "Standard on Water Mist Fire Protection Systems."

3.3.1.3 Foam-Water Sprinkler and Spray Systems. Certain fires, such as those involving flammable liquids, respond well to foam suppression. Consideration should be given to the use of foam sprinkler and spray systems. Foam sprinkler and spray systems should conform to appropriate standards such as NFPA 16, "Standard for the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems," NFPA 16A, "Standard for the Installation of Closed-Head Foam-Water Sprinkler Systems," NFPA 11, "Standard for Low-Expansion Foam," and NFPA 11A, "Standard for Medium- and High-Expansion Foam Systems."

3.3.2 Gaseous Fire Suppression

Where gas suppression systems are installed, openings in the area should be adequately sealed or the suppression system should be sized to compensate for the loss of the suppression agent through floor drains and other openings. (Also see Regulatory Position 4.1.5.)

Where total flooding gas extinguishing systems are used, area intake and exhaust ventilation dampers should be controlled in accordance with appropriate standards to maintain the necessary gas concentration. (See NFPA 12, "Standard on Carbon Dioxide Extinguishing Systems," NFPA 12A, "Standard on Halon 1301 Fire Extinguishing Systems," and NFPA 2001, "Standard on Clean Agent Fire Extinguishing Systems.") (Also see Regulatory Position 4.1.4.4.)

The adequacy of gas suppression systems and protected area boundary seals to contain the gas suppressant should be tested as specified in the applicable NFPA Standards.

Manually actuated gaseous suppression systems should not be used as the primary suppression system for protecting structures, systems, and components important to safety. Manually actuated gaseous systems are acceptable as a backup to automatic water-based fire suppression systems.

3.3.2.1 Carbon Dioxide (CO_2) Systems. Carbon dioxide extinguishing systems should comply with the requirements of NFPA 12, "Carbon Dioxide Extinguishing Systems." Where automatic carbon dioxide systems are used, they should be equipped with a pre-discharge alarm system and a discharge delay to permit personnel egress. Provisions for locally disarming automatic carbon dioxide systems should be key locked and under strict administrative control. Automatic carbon dioxide extinguishing systems should not be disarmed unless controls as described in Regulatory Position 2.4 are provided.

In addition to the guidelines of NFPA 12, preventive maintenance and testing of the systems, including verifying agent quantity of high-pressure CO_2 cylinders, should be done.

Particular consideration should also be given to:

a. The minimum required CO_2 concentration, distribution, soak time, and ventilation control;

b. The anoxia and toxicity hazards associated with CO_2;

c. The possibility of secondary thermal shock (cooling) damage;

d. Conflicting requirements for venting during CO_2 injection to prevent over pressurization versus sealing to prevent loss of agent; and

e. Location and selection of the activating detectors.

3.3.2.2 Halon. Halon fire extinguishing systems should comply with the requirements of NFPA 12A. Where automatic Halon systems are used, they should be equipped with a pre-discharge alarm and a discharge delay to permit personnel egress. Provisions for locally disarming automatic Halon systems should be key locked and under strict administrative control. Automatic Halon extinguishing systems should not be disarmed unless controls as described in Regulatory Position 2.4 are provided.

In addition to the guidelines of NFPA 12A, preventive maintenance and testing of the systems, including verifying agent quantity of the Halon cylinders, should be done.

Particular consideration should also be given to:

a. The minimum required Halon concentration, distribution, soak time, and ventilation control,

b. The toxicity of Halon,

c. The toxicity and corrosive characteristics of the thermal decomposition products of Halon, and

d. The location and selection of the activating detectors.

3.3.2.3 Clean Agents. Halon alternative (or "clean agent") fire extinguishing systems should comply with applicable standards such as NFPA 2001. Only listed or approved agents should be used. Provisions for locally disarming automatic systems should be key locked and under strict administrative control. Automatic extinguishing systems should not be disarmed unless controls as described in Regulatory Position 2.4 are provided.

In addition to the guidelines of NFPA 2001, preventive maintenance and testing of the systems, including verifying agent quantity of the clean agent cylinders/containers, should be done.

Particular consideration should also be given to:

a. The minimum required clean agent concentration, distribution, soak time, and ventilation control,

b. The toxicity of the clean agent,

c. The toxicity and corrosive characteristics of the thermal decomposition products of the clean agent,

d. Conflicting requirements for venting during clean agent injection to prevent over pressurization versus sealing to prevent the loss of agent, and

e. The effectiveness of the particular clean agent at its design concentration for the protected hazard.

f. The location and selection of the activating detectors.

The guidance in Regulatory Position 3.3 is based on Appendix R to 10 CFR Part 50, CMEB 9.5-1, and IN 92-28.

3.4 Manual Suppression Systems and Equipment

A manual firefighting capability should be provided throughout the plant to limit the extent of fire damage. Standpipes, hydrants, and portable equipment consisting of hoses, nozzles, and extinguishers should be provided for use by properly trained firefighting personnel.

3.4.1 Standpipes and Hose Stations

Interior manual hose installation should be able to reach any location that contains, or could present a fire exposure hazard to, equipment important to safety with at least one effective hose stream. To accomplish this, standpipes with hose connections equipped with a maximum of 30.5 m (100 feet) of 38 mm (1-1/2-inches) woven-jacket, lined fire hose and suitable nozzles should be provided in all buildings on all floors. These systems should conform to NFPA 14, "Standard for the Installation of Standpipe and Hose Systems," for sizing, spacing, and pipe support requirements for Class III standpipes.

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.

The proper type of hose nozzle to be supplied to each area should be based on the fire hazard analysis. The usual combination spray/straight-stream nozzle should not be used in areas where the straight stream can cause unacceptable mechanical damage. Fixed fog nozzles should be provided at locations where high-voltage shock hazards exist. All hose nozzles should have shutoff capability. Guidance on safe distances for water application to live electrical equipment may be found in the "NFPA Fire Protection Handbook," Chapter 6, Eighteenth Edition.

Fire hose should meet the recommendations of NFPA 1961, "Standard on Fire Hose," and should be hydrostatically tested in accordance with the recommendations of NFPA 1962, "Standard for the Care, Use, and Service Testing of Fire Hose Including Couplings and Nozzles."

3.4.2 Hydrants and Hose Houses

Outside manual hose installation should be sufficient to provide an effective hose stream to any onsite location where fixed or transient combustibles could jeopardize equipment important to safety. Hydrants should be installed approximately every 76 m (250 ft) on the yard main system. A hose house equipped with hose and combination nozzle and other auxiliary equipment

recommended in NFPA 24 should be provided as needed, but at least every 305 m (1,000 ft). Alternatively, mobile means of providing hose and associated equipment, such as hose carts or trucks, may be used. When provided, such mobile equipment should be equivalent to the equipment supplied by three hose houses.

Threads compatible with those used by local fire departments should be provided on all hydrants, hose couplings, and standpipe risers. Alternatively, a sufficient number of hose thread adapters may be provided.

Fire hose should be hydrostatically tested in accordance with the recommendations of NFPA 1962. Fire hose stored in outside hose houses should be tested annually.

3.4.3 Manual Foam

For flammable and combustible liquid fire hazards, consideration should be given to the use of foam systems for manual fire suppression protection. These systems should comply with the requirements of NFPA 11, NFPA 11A, and NFPA 11C, "Standard for Mobile Foam Apparatus," as applicable.

3.4.4 Fire Extinguishers

Fire extinguishers should be provided in areas that contain or could present a fire exposure hazard to equipment important to safety. Dry chemical extinguishers should be installed with due consideration given to possible adverse effects on equipment important to safety installed in the area. NFPA 10, "Standard for Portable Fire Extinguishers," provides guidance on the use and application of fire extinguishers.

The guidance in Regulatory Position 3.4 is based on Appendix R to 10 CFR Part 50 and CMEB 9.5-1.

3.5 Manual Firefighting Capabilities

3.5.1 Fire Brigade

A site fire brigade trained and equipped for fire fighting should be established and should be on site at all times to ensure adequate manual firefighting capability for all areas of the plant containing structures, systems, and components important to safety. The fire brigade leader should have ready access to keys for any locked doors.

Guidance on fire brigade training and qualification is provided in Regulatory Position 1.6.4.

The guidelines of NFPA 600 are considered appropriate criteria for organizing, training, and operating a plant fire brigade.

3.5.1.1 Fire Brigade Staffing. The fire brigade should be at least five members on each shift. The shift supervisor should not be a member of the fire brigade.

3.5.1.2 Equipment. The equipment provided for the brigade should consist of personal protective equipment such as turnout coats, bunker pants, boots, gloves, hard hats, emergency communications equipment, portable lights, portable ventilation equipment, and portable extinguishers. Self-contained breathing apparatus using full-face positive-pressure masks approved by NIOSH (National Institute for Occupational Safety and Health — approval formerly given by the U.S. Bureau of Mines) should be provided for fire brigade, damage control, and control room personnel. At least 10 masks should be available for fire brigade personnel. Control room personnel may be furnished breathing air by a manifold system piped from a storage reservoir if practical. Service or rated operating life should be at least one-half hour for the self-contained units. Additional guidance is provided in NFPA 1404, "Standard for a Fire Department Self-Contained Breathing Apparatus Program."

At least a 1-hour supply of breathing air in extra bottles should be located on the plant site for each unit of self-contained breathing apparatus. In addition, an onsite 6-hour supply of reserve air should be provided for the fire brigade personnel and arranged to permit quick and complete replenishment of exhausted air supply bottles as they are returned. If compressors are used as a source of breathing air, only units approved for breathing air should be used and the compressors should be operable assuming a loss of offsite power. Special care should be taken to locate the compressor in areas free of dust and contaminants.

During refueling and maintenance periods, adequate self-contained breathing apparatus should be provided near the containment entrances for firefighting and damage control personnel. These units should be independent of any breathing apparatus or air supply systems provided for general plant activities and should be clearly marked as emergency equipment.

3.5.1.3 Procedures and Pre-fire Plans. Procedures should be established to control actions by the fire brigade on notification by the control room of a fire, and to define firefighting strategies. These procedures should include:

a. Actions to be taken by control room personnel to notify the fire brigade upon report of a fire or receipt of an alarm on the control room fire alarm panel, for example, announcing the location of the fire over the PA system, sounding fire alarms, and notifying the shift supervisor and the fire brigade leader of the type, size, and location of the fire.

b. Actions to be taken by the fire brigade after notification by the control room of a fire, for example, assembling in a designated location, receiving directions from the fire brigade leader, and discharging specific firefighting responsibilities, including selection and transportation of firefighting equipment to the fire location, selection of protective equipment, operating instructions for use of fire suppression systems, and use of preplanned strategies for fighting fires in specific areas.

c. Define the strategies for fighting fires in all plant areas. These strategies should designate:

    i. Fire hazards in each area covered by the specific pre-fire plans.

ii. Fire suppression agents best suited for extinguishing the fires associated with the fire hazards in that area and the nearest location of these suppression agents.

iii. Most favorable direction from which to attack a fire in each area in view of the ventilation direction, access hallways, stairs, and doors that are most likely to be free of fire, and the best station or elevation for fighting the fire. All access and egress routes that involve locked doors should be specifically identified in the procedure with the appropriate precautions and methods for access specified.

iv. Plant systems that should be managed to reduce the damage potential during a local fire and the location of local and remote controls for such management (e.g., any hydraulic or electrical systems in the zone covered by the specific firefighting procedure that could increase the hazards in the area because of over pressurization or electrical hazards).

v. Vital heat-sensitive system components that need to be kept cool while fighting a local fire. In particular, hazardous combustibles that need cooling should be designated.

vi. Organization of firefighting brigades and the assignment of special duties according to job title so that all firefighting functions are covered by any complete shift personnel complement. These duties include command control of the brigade, transporting fire suppression and support equipment to the fire scenes, applying the extinguishing agent to the fire, communication with the control room, and coordination with outside fire departments.

vii. Potential radiological and toxic hazards in fire zones.

viii. Ventilation system operation that ensures desired plant air distribution when the ventilation flow is modified for fire containment or smoke clearing operation.

ix. Operations requiring control room and shift engineer coordination or authorization.

x. Instructions for plant operators and general plant personnel during fire.

xi. Communications between the fire brigade leader, fire brigade, offsite mutual aid responders, control room, and licensee’s emergency response organization.

Appropriate firefighting procedures should identify the techniques and equipment for the use of water in fighting electrical cable fires in nuclear plants, particularly in areas containing a high concentration of electric cables with plastic insulation. Additional guidance on pre-fire planning is provided in NFPA 1620, "Recommended Practice for Pre-Incident Planning."

3.5.1.4 Performance Assessment/Drill Criteria. Fire brigade drills should be performed in the plant so that the fire brigade can practice as a team. Drills should be performed quarterly for each shift fire brigade. Each fire brigade member should participate in at least two drills per year.

A sufficient number of these drills, but not less than one for each shift fire brigade per year, should be unannounced to determine the firefighting readiness of the plant fire brigade, brigade leader, and fire protection systems and equipment. Persons planning and authorizing an unannounced drill should ensure that the responding shift fire brigade members are not aware that a drill is being planned until it has begun. At least one drill per year should be performed on a "back shift" for each shift fire brigade.

The drills should be preplanned to establish the training objectives of the drill and should be critiqued to determine how well the training objectives have been met. Unannounced drills should be planned and critiqued by members of the management staff responsible for plant safety and fire protection. Performance deficiencies of a fire brigade or of individual fire brigade members should be remedied by scheduling additional training for the brigade or members.

Unsatisfactory drill performance should be followed by a repeat drill within 30 days.

The local fire department should be invited to participate at least annually.

At 3-year intervals, a randomly selected unannounced drill should be critiqued by qualified individuals independent of the licensee's staff. A copy of the written report from such individuals should be available for NRC review.

Drills should include the following:

a. Assessment of fire alarm effectiveness, time required to notify and assemble the fire brigade, and selection, placement, and use of equipment and firefighting strategies.

b. Assessment of each brigade member's knowledge of his or her role in the firefighting strategy for the area assumed to contain the fire. Assessment of the brigade members' conformance with established plant firefighting procedures and use of firefighting equipment, including self-contained emergency breathing apparatus, communication, lighting, and ventilation.

c. The simulated use of firefighting equipment required to cope with the situation and type of fire selected for the drill. The area and type of fire chosen for the drill should differ from those used in the previous drills so that brigade members are trained in fighting fires in various plant areas. The situation selected should simulate the size and arrangement of a fire that could reasonably occur in the area selected, allowing for fire development during the time required to respond, obtain equipment, and organize for the fire, assuming loss of automatic suppression capability.

d. Assessment of the brigade leader's direction of the firefighting effort as to thoroughness, accuracy, and effectiveness.

Drill records should be retained for a period of 3 years and made available for NRC inspection. (See Regulatory Position 1.6.4 for additional guidance on drill records.)

3.5.2 Offsite Manual Fire-Fighting Resources

Onsite fire brigades typically fulfill the role of first responder, but may not have sufficient personnel, equipment, and capability to handle all possible fire events. Arrangements with offsite fire services may be necessary to augment onsite firefighting capabilities, consistent with the fire hazards analysis and pre-fire planning documents.

3.5.2.1 Capabilities. The local offsite fire departments providing back up manual firefighting resources should have the following capabilities:

a. Personnel and equipment with capacities consistent with those assumed in the plant's fire hazards analysis and pre-fire plans.

b. Hose threads or adapters to connect with onsite hydrants, hose couplings, and standpipe risers. (Regulatory Position 3.4.2 states that onsite fire suppression water systems should have threads compatible with those used by local fire departments or a sufficient number of thread adapters available.)

3.5.2.2 Training. Local offsite fire department personnel providing back up manual firefighting resources should be trained in:

a. Operational precautions when fighting fires on nuclear power plant sites and the need for radiological protection of personnel and the special hazards associated with a nuclear power plant site.

b. The procedures for notification and expected roles of the offsite responders.

c. Site access procedures and the identity (by position and title) of the individual in the onsite organization who will control the responders' support activities. Offsite response support personnel should be provided with appropriate identification cards where required.

d. Fire protection authorities, responsibilities, and accountabilities with regard to responding to a plant fire, including the fire event command structure between the plant fire brigade and offsite responders.

e. Plant layout, plant fire protection systems and equipment, plant fire hazards, and pre-fire response plans and procedures.

3.5.2.3 Agreement/Plant Exercise. Written mutual aid agreements should be established between the utility and the offsite fire departments that are assumed in the fire hazards analysis and pre-fire plans to support response to a plant fire. These agreements should delineate fire protection authorities, responsibilities, and accountabilities with regard to responding to plant fire or emergency events, including the fire event command structure between the plant fire brigade and offsite responders.

The plant fire brigade drill schedule should provide for periodic local fire department participation (at least annually). These drills should effectively exercise the fire event command

structure between the plant fire brigade and offsite responders. (See Regulatory Position 3.5.1.4 for guidance on conduct and evaluation of fire brigade drills.) Offsite fire department response should be tested periodically in conjunction with the required exercises of the radiological emergency response plan required by 10 CFR 50.47.

The guidance in Regulatory Position 3.5 is based on Appendix R to 10 CFR Part 50, NUREG-0654, and CMEB 9.5-1.

4. BUILDING DESIGN/PASSIVE FEATURES

4.1 General Building and Building System Design

This section provides guidance on building layout (e.g., fire areas and zones), materials of construction, and building system design (e.g., electrical, HVAC, lighting, and communication systems) important to effective fire prevention and protection. Guidance for passive fire barriers is provided in Regulatory Position 4.2.

4.1.1 Combustibility of Building Components and Features

According to GDC 3, noncombustible and heat resistant materials must be used wherever practical throughout the unit. Interior wall and structural components, thermal insulation materials, radiation shielding materials, and soundproofing should be noncombustible.

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

4.1.1.1 Interior Finish. Interior finishes should be noncombustible. The following materials are acceptable for use as interior finish without evidence of test and listing by a recognized testing laboratory:

- Plaster, acoustic plaster, gypsum plasterboard (gypsum wallboard), either plain, wallpapered, or painted with oil- or water-base paint,

- Ceramic tile, ceramic panels,

- Glass, glass blocks,

- Brick, stone, concrete blocks, plain or painted,

- Steel and aluminum panels, plain, painted, or enameled, and

- Vinyl tile, vinyl-asbestos tile, linoleum, or asphalt tile on concrete floors.

Suspended ceilings and their supports should be of noncombustible construction. Concealed spaces should be devoid of combustibles except as noted in Regulatory Position 6.1.2, Control Room Complex.

In situ fire hazards should be identified and suitable protection provided.

4.1.1.2 Testing and Qualification. Interior finishes should be noncombustible (see Definitions section of this guide) or listed by an approving laboratory for:

a. Surface flame spread rating of 25 or less, and a smoke development rating of 450 or less, when tested under ASTM E-84, "Standard Test Method for Surface Burning Characteristics of Building Materials," and

b. Potential heat release of 8141 kJ/kg (3500 Btu/lb) or less when tested under ASTM D3286 or NFPA 259, "Standard Test Method for Potential Heat of Building Materials."[(1)]

c. Floor covering critical radiant flux should be determined by testing in accordance with NFPA 253, “Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source.”

The guidance in Regulatory Position 4.1.1 is based on GDC 3, Appendix R to 10 CFR Part 50, ASB 9.5-1, and CMEB 9.5-1.

4.1.2 Compartmentation, Fire Areas and Zones

In accordance with GDC 3, structures, systems, and components important to safety must be designed and located to minimize the probability and effect of fires and explosions. The concept of compartmentation meets GDC 3, in part, by utilizing passive fire barriers to subdivide the plant into separate areas or zones. These fire areas or zones serve the primary purpose of confining the effects of fires to a single compartment or area, thereby minimizing the potential for adverse effects from fires on redundant structures, systems, and components important to safety.

4.1.2.1 Fire Areas. A fire area is defined as that portion of a building or plant that is separated from other areas by fire barriers, including components of construction such as beams, joists, columns, penetration seals or closures, fire doors, and fire dampers. Fire barriers that define the boundaries of a fire area should have a fire resistance rating of 3 hours or more and should be provided:

a. To separate structures, systems, and components important to safety from any potential fires in non-safety-related areas that could affect their ability to perform their safety function;

b. To separate redundant success paths of systems and components important to safety from each other so that both are not subject to damage from a single fire;

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

c. To separate individual units on a multiple-unit site unless the requirements of General Design Criterion 5 are met with respect to fires.

Fire areas should be established on the basis of the fire hazards analysis. Particular design attention to the use of separate isolated fire areas for redundant cables will help to avoid loss of redundant cables important to safety. Separate fire areas should also be employed to limit the spread of fires between components, including high concentrations of cables important to safety that are major fire hazards within a safety division.

Where fire area boundaries are not 3-hour rated, or not wall-to-wall or floor-to-ceiling boundaries with all penetrations sealed to the fire rating of the boundaries, an evaluation should be performed to assess the adequacy of the fire area boundaries (i.e., barriers) to determine whether the boundaries will withstand the hazards associated with the area and, as necessary, protect important equipment within the area from a fire outside the area. Unsealed openings should be identified and considered when evaluating the overall effectiveness of the barrier (See Regulatory Position 1.4.3 for positions related to barrier evaluations. See Regulatory Position 4.2.1 for positions related to fire barrier testing and acceptance.)

If a wall or floor/ceiling assembly contains major unprotected openings such as hatchways and stairways, plant locations on either side of such a barrier should be considered as part of a single fire area. If success path A is separated by a cumulative horizontal distance of 6.1 m (20 feet) from success path B, with no intervening combustible materials or fire hazards, and both elevations are provided with fire detection and suppression, the area would be considered acceptable.

Exterior walls, including penetrations, should be qualified as rated fire barriers if they are required to separate safe shutdown equipment on the interior of the plant from the redundant equipment located in the immediate vicinity of the exterior wall, if they separate plant areas important to safety from non-safety-related areas that present a significant fire exposure to the areas important to safety, or if otherwise designated by the FSAR or fire hazards analysis.

An exterior yard area without fire barriers should be considered as one fire area. The area may consist of several fire zones (see Regulatory Position 4.1.2.2).

4.1.2.2 Fire Zones. Fire zones are subdivisions of a fire area and are typically based on fire hazards analyses that demonstrate that the fire protection systems and features within the fire zone provide an appropriate level of protection for the associated hazards. Fire zone concepts may be used to establish zones within fire areas where further subdivision into additional fire areas is not practical on the basis of existing plant design and layout.

Evaluations by some licensees made prior to Appendix R were based on fire zones that do not meet the strict definition of fire areas. In some cases, the separation of redundant success paths within the fire zone boundaries and the separation between fire zones do not comply with the separation requirements of Appendix R. Such configurations may be acceptable under the exemption process.

An exterior yard area considered as one fire area may consist of several fire zones. The boundaries of the fire zones should be determined by a fire hazards analysis. The protection for redundant, alternative, dedicated, or backup shutdown systems within a yard area should be determined on the basis of the largest postulated fire that is likely to occur and the resulting damage. The boundaries of such damage should be justified with a fire hazards analysis. The analysis should consider the degree of spatial separation between divisions; the presence of in situ and transient combustibles, including vehicular traffic; grading; available fire protection; sources of ignition; and the vulnerability and criticality of the shutdown related systems.

4.1.2.3 Access and Egress Design. Provisions should be made for personnel access to and escape routes from each fire area. Under emergency conditions, prompt ingress into certain areas important to safety should be ensured to enable manual fire suppression and safe shutdown of a nuclear power plant.

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 2 hours and self-closing Class B fire doors. Fire exit routes should be clearly marked.

Prompt emergency ingress into electrically locked areas by essential personnel should be ensured through the combined use and provision of the following features.

a. Reliable and uninterruptible auxiliary power to the entire electrical locking system, including its controls.

b. Electrical locking devices that are required to fail in the secure mode for security purposes, with secure mechanical means and associated procedures to override the devices upon loss of both primary and auxiliary power (e.g., key locks with keys held by appropriate personnel who know when and how to use them).

c. Periodic tests of all locking systems and mechanical overrides to confirm their operability and their capability to switch to auxiliary power.

Also see Regulatory Positions 4.1.6 and 4.1.7 for guidance related to lighting and communication capabilities during fires.

The guidance in Regulatory Position 4.1.2 is based on GDC 3, Appendix R to 10 CFR Part 50, CMEB 9.5-1, GL 83-33, GL 86-10, BL 81-03, and IN 84-09.

4.1.3 Electrical Cable System Fire Protection Design

4.1.3.1 Cable Design. Electric cable construction should pass the flame test in IEEE Standard 383, "Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations," or IEEE Standard 1202, "Standard for Flame Testing of Cables for Use in Cable Trays in Industrial and Commercial Occupancies." For cable installations in operating plants and plants under construction prior to July 1, 1976, that do not meet the IEEE

Standard 383 flame test requirements, all cables should be covered with an approved flame retardant coating and properly derated, or be protected by automatic suppression.

4.1.3.2 Raceway/Cable Tray Construction. Only metal should be used for cable trays. Only metallic tubing should be used for conduit. Thin-wall metallic tubing should not be used. Flexible metallic tubing should only be used in short lengths to connect components to equipment. Other raceways should be made of noncombustible material. Cable raceways should be used only for cables.

4.1.3.3 Electrical Cable System Fire Detection and Suppression. Redundant cable systems important to safety 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 3 hours. These fire areas that contain cable trays important to safety should be provided with fire detection. Cable trays should be accessible for manual fire fighting and 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.

Manual hose standpipe systems may be relied upon to provide the primary fire suppression (in lieu of automatic water suppression systems) for cable trays of a single division important to safety that are separated from redundant safety divisions by a fire barrier with a minimum rating of 3 hours and are normally accessible for manual fire fighting if all of the following conditions are met.

a. The number of equivalent[(2)] standard 610-mm- (24-inch-) wide cable trays (both important to safety and non-safety-related) in a given fire area is 6 or less;

b. The cabling does not provide instrumentation, control, or power to systems required to achieve and maintain hot 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.

In other areas where it may not be possible because of other overriding design features necessary for reasons of nuclear safety to separate redundant cable systems important to safety by 3-hour-rated fire barriers, or if cable trays are not accessible for manual firefighting, cable trays should be protected by an automatic fire suppression system.

4.1.3.4 Electrical Cable Separation. Redundant systems used to mitigate the consequences of design basis accidents but not necessary for safe shutdown may be lost to a single exposure fire. However, protection should be provided so that a fire within only one such system will not damage the redundant system. Therefore, the separation criteria of Regulatory Position 5.5 apply only to the electrical cabling needed to support the systems that are used for safe shutdown. All other redundant Class 1E and associated electrical cables should meet the separation criteria of Regulatory Guide 1.75.

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[2] Trays exceeding 610 mm (24 inches) should be counted as two trays; trays exceeding 1220 mm (48 inches) should be counted as three trays, regardless of tray fill.

When the electrical cabling is covered by separation criteria required for both safe shutdown and accident mitigation, the more stringent criteria of Regulatory Position 5.5 apply. [Note that compliance with safe shutdown requirements may be achieved without separation of redundant Class 1E cabling by providing alternative, dedicated, or backup shutdown capability (see Regulatory Position 5.6); however, this does not preclude the separation criteria of Regulatory Guide 1.75 for redundant Class 1E and associated cables used in accident mitigation.]

For plants with a Construction Permit issued prior to July 1, 1976, where cables important to safety do not satisfy the provisions of Regulatory Guide 1.75, all exposed cables should be covered with an approved fire retardant coating or a fixed automatic water fire suppression system should be provided.

4.1.3.5 Transformers. Transformers that present a fire hazard to equipment important to safety should be protected as described in Regulatory Position 7.3 of this guide.

4.1.3.6 Electrical Cabinets. Electrical cabinets present an ignition source for fires and a potential for explosive electrical faults that can result in damage not only to the cabinet of origin, but also to equipment, cables, and other electrical cabinets in the vicinity of the cabinet of origin. Fire protection systems and features provided for the general area containing the cabinet may not be adequate to prevent damage to adjacent equipment, cables, and cabinets following an energetic electrical fault. Energetic electrical faults are more of a concern with high-voltage electrical cabinets (i.e., 480 volts and above). High- voltage cabinets should be provided with adequate spatial separation or substantial physical barriers to minimize the potential for an energetic electrical fault to damage adjacent equipment, cables, or cabinets important to safety.

Rooms containing electrical cabinets important to safety should be provided with area-wide automatic fire detection, automatic fire suppression, and manual fire suppression capability.

Electrical cabinets containing a quantity of combustible materials (e.g., cabling) sufficient to propagate a fire outside the cabinet of fire origin should be provided with in-cabinet automatic fire detection.

The guidance in Regulatory Position 4.1.3 is based on APCSB 9.5-1, CMEB 9.5-1, and Mattson Memo 1983.

4.1.4 HVAC Design

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 caused by the fire, causing loss of control for ventilating, exhausting, or isolating a given fire area.

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

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. 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 should include containment functions for protecting the public and maintaining habitability for operations personnel.

Fresh air supply intakes to areas containing equipment or systems important to safety 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.

Where total flooding gas extinguishing systems are used, area intake and exhaust ventilation dampers should be controlled in accordance with NFPA 12 and NFPA 12A to maintain the necessary gas concentration. (Also see Regulatory Position 3.3.2.)

4.1.4.1 Combustibility of Filter Media. Filters for particulate and gaseous effluents may be fabricated of combustible media (e.g., HEPA and charcoal filters). The ignition and burning of these filters may result in a direct release of radioactive material to the environment, or may provide an unfiltered pathway upon failure of the filter. Filter combustion may spread fire to other areas.

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 components important to safety should be protected as determined by the fire hazards analysis.

4.1.4.2 Smoke Control/Removal. Smoke from fires can be toxic, corrosive, and may obscure visibility for emergency egress and access to plant areas. Smoke control and removal may be necessary to support manual suppression activities and safe shutdown operations.

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 plant areas important to safety. 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, "Guide for Smoke and Heat Venting," for additional guidance on smoke control).

4.1.4.3 Habitability. Protection of plant operations staff from the effects of fire and fire suppression (e.g., gaseous suppression agents) may be necessary to ensure safe shutdown of the plant. For control room evacuation, egress pathways and remote control stations should also be habitable. Consideration should be given to protection of safe shutdown areas from infiltration of gaseous suppression agents. The capability to ventilate, exhaust, or isolate is particularly important to ensure the habitability of rooms or spaces that should be attended in an emergency.

In the design, provision should be made for personnel access to and escape routes from each fire area. Habitability of the following areas should be considered.

- Control room
- Post-fire safe shutdown areas
- Personnel access and egress pathways

Stairwells should be designed to minimize smoke infiltration during a fire. Staircases may serve as escape routes and access routes for fire fighting. Fire exit routes should be clearly marked. Stairwells, elevators, and chutes should be enclosed in fire-rated construction with automatic fire doors at least equal to the enclosure construction, at each opening into the building. Elevators should not be used during fire emergencies.

4.1.4.4 Fire Dampers. Redundant safe shutdown components may be separated by fire-resistant walls, floors, enclosures, or other types of barriers. For the fire barriers to be effective in limiting the propagation of fire, ventilation duct penetrations of fire barriers should be protected by means of fire dampers that are arranged to automatically close in the event of fire. Additional guidance is provided in NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems." (Also see Regulatory Position 4.2.1.3.)

The guidance in Regulatory Position 4.1.4 is based on CMEB 9.5-1 and IN 83-69.

4.1.5 Drainage

Floor drains sized to remove expected firefighting water without flooding equipment important to safety should be provided in 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 equipment important to safety in the area. Facility design should ensure that fire water discharge in one area does not impact equipment important to safety in adjacent areas.

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 (see Regulatory Position 3.3.2).

Drains in areas containing combustible liquids should have provisions for preventing the backflow of combustible liquids to plant areas important to safety through the interconnected drain systems.

Water drainage from areas that may contain radioactivity should be collected, sampled, and analyzed before discharge to the environment.

The guidance in Regulatory Position 4.1.5 is based on CMEB 9.5-1.

4.1.6 Emergency Lighting

Emergency lighting should be provided as necessary to support fire suppression actions, safe shutdown operations, and emergency egress during a fire event.

4.1.6.1 Egress Safety. Emergency lighting should be provided in support of emergency egress design guidelines in Regulatory Position 4.1.2.3.

4.1.6.2 Post-Fire Safe Shutdown. Lighting is vital to post-fire safe shutdown and emergency response in the event of fire. Suitable fixed and portable emergency lighting should be provided as follows.

a. Fixed self-contained lighting consisting of fluorescent or sealed-beam units with individual 8-hour minimum battery power supplies should be provided in areas needed for operation of safe shutdown equipment and for access and egress routes thereto.

   The level of illumination provided by emergency lighting in access routes to and in areas where shutdown functions are performed is a level that is sufficient to enable an operator to reach that area and perform the shutdown functions. At the remote shutdown panels, the illumination levels should be sufficient for control panel operators. The bases for estimating these levels of lighting are the guidelines contained in Section 9.5.3 of the Standard Review Plan, NUREG-0800. If a licensee has provided emergency lighting per Section III.J of Appendix R, the licensee should verify by field testing that this lighting is adequate to perform the intended tasks.

   Routine maintenance and initial and periodic field testing of emergency lighting systems should ensure their ability to support access, egress, and operations activities for the full 8-hour period accounting for anticipated environmental conditions, battery conditions, and bulb life.

b. 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.

If emergency lights are powered from a central battery or batteries, the distribution system should contain such protective devices that a fire in one area will not cause a loss of emergency lighting in any unaffected area needed for safe shutdown operations.

The guidance in Regulatory Position 4.1.6 is based on Appendix R to 10 CFR Part 50, CMEB 9.5-1, GL 86-10, IN 95-36, IP 64100, TI 2515/62, and Vollmer Memo 1983b.

4.1.7 Communications

The communication system design should provide effective communication between plant personnel in all vital areas during fire conditions under maximum potential noise levels.

Two-way voice communications are vital to safe shutdown and emergency response in the event of fire. Suitable communication devices should be provided as follows.

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

b. A portable radio communications system should be provided for use by the fire brigade and other operations personnel required to achieve safe plant shutdown. This system should not interfere with the communications capabilities of the plant security force. Fixed repeaters installed to permit use of portable radio communication units should be protected from exposure fire damage. Pre-operational and periodic testing should demonstrate that the frequencies used for portable radio communication will not affect the actuation of protective relays.

The guidance in Regulatory Position 4.1.7 is based on NUREG-0800 and CMEB 9.5-1.

4.1.8 Explosion Prevention

In situ and transient explosion hazards should be identified and suitable protection provided. Transient explosion hazards that cannot be eliminated should be controlled and suitable protection provided. (See Regulatory Position 2.1 regarding control of combustibles.)

Miscellaneous storage and piping for flammable or combustible liquids or gases should not create a potential exposure hazard to systems important to safety or the fire protection systems that serve those areas. (Also see Regulatory Positions 2.1.3 and 7.5.)

Systems or processes that involve hydrogen supplies (e.g., generator cooling systems and reactor coolant hydrogen addition systems) and those that may evolve hydrogen or explosive gases (e.g., waste gas and solid radioactive waste processing systems) should be designed to prevent development of explosive mixtures by limiting the concentration of explosive gases and vapors within enclosures to less than 50% of the lower explosive limit, or by limiting oxygen within systems containing hydrogen. Hydrogen distribution and supply systems should include design features that mitigate the consequences of system damage, such as excess flow valves or flow restrictors, double-walled pipe with annulus leak detection, and rupture diaphragms. (Also see Regulatory Position 7.5.)

The construction, installation, operation, and maintenance of bulk gas (including liquefied gas) storage and the related loading and dispensing systems should comply with good industry practice and the relevant NFPA Standards, as applicable (e.g., NFPA 50A, “Standard for Gaseous Hydrogen Systems at Consumer Sites,” NFPA 50B, "Standard for Liquefied Hydrogen Systems at Consumer Sites," and NFPA 54, "National Fuel Gas Code").

If the potential for an explosive mixture of hydrogen and oxygen exists in off gas systems, the systems should either be designed to withstand the effects of a hydrogen explosion or be provided with dual gas analyzers with automatic control functions to preclude the formation or buildup of explosive mixtures.

The guidance in Regulatory Position 4.18 is in NUREG-0800 and CMEB 9.5-1.

4.2 Passive Fire Resistive Features

4.2.1 Structural Fire Barriers

Fire barriers are those components of construction (walls, floors, and their supports), including beams, joists, columns, penetration seals or closures, fire doors, and fire dampers that are rated by approving laboratories in hours of resistance to fire and are used to prevent the spread of fire.

Where exact replication of a tested configuration cannot be achieved, the field installation should meet all of the following criteria.

a. The continuity of the fire barrier material is maintained;

b. The thickness of the barrier is maintained;

c. The nature of the support assembly is unchanged from the tested configuration;

d. The application or "end use" of the fire barrier is unchanged from the tested configuration;

e. The configuration has been reviewed by a qualified fire protection engineer and found to provide an equivalent level of protection.

See Regulatory Position 4.1.2 for additional guidance on the design of fire barriers relative to compartmentation and separation of equipment.

4.2.1.1 Wall, Floor, and Ceiling Assemblies. Wall, floor, and ceiling construction should be noncombustible (see Regulatory Position 4.1.1). NFPA 221, "Standard for Fire Walls and Fire Barrier Walls," can be used as guidance for construction of fire barrier walls. Materials of construction for walls, floors, and ceilings serving as fire barriers should be rated by approving laboratories in hours of resistance to fire.

Building design should ensure that openings through fire barriers are properly protected. Openings through fire barriers that separate fire areas should be sealed or closed to provide a fire resistance rating at least equal to that required of the barrier itself. The construction and installation techniques for penetrations through fire barriers should be qualified by fire endurance tests (see Regulatory Position 4.2.1.5, Testing and Qualification).

4.2.1.2 Fire Doors. Building design should ensure that door openings are properly protected. These openings should be protected with fire doors that have been qualified by a fire test. The construction and installation techniques for doors and door openings through fire barriers should be in accordance with the door manufacturer’s recommendations and the tested configuration.

Modifications to fire doors should be evaluated. Where a door is part of a fire area boundary, and a modification does not affect the fire rating (for example, installation of security

"contacts"), no further analysis need be performed. If the modifications could reduce the fire rating (for example, installation of a vision panel), the fire rating of the door should be reassessed to ensure that it continues to provide an equivalent level of protection to a rated fire door.

Fire doors should be self-closing or provided with closing mechanisms and should be inspected semiannually to verify that automatic hold-open, release, and closing mechanisms and latches are operable. One of the following measures should be provided to ensure they will protect the opening as required in case of fire.

a. Fire doors should be kept closed and electrically supervised at a continuously manned location;

b. Fire doors should be locked closed and inspected weekly to verify that the doors are in the closed position;

c. Fire doors should be provided with automatic hold-open and release mechanisms and inspected daily to verify that doorways are free of obstructions; or

d. Fire doors should be kept closed and inspected daily to verify that they are in the closed position.

Areas protected by automatic total flooding gas suppression systems should have electrically supervised self-closing fire doors or should satisfy option (a) above.

Additional guidance for fire doors is provided in NFPA 80, "Standard for Fire Doors and Fire Windows."

4.2.1.3 Fire Dampers. Building design should ensure that ventilation openings are properly protected. These openings should be protected with fire dampers that have been fire tested. In addition, the construction and installation techniques for ventilation openings through fire barriers should be qualified by fire endurance tests. For ventilation ducts that penetrate or terminate at a fire wall, guidance in NFPA 90A indicates that ventilation fire dampers should be installed within the fire wall penetration for barriers with a fire rating greater than or equal to 2 hours. NFPA 90A requires that fire dampers be installed in all air transfer openings within a rated wall.

Until recently, the only industry standard governing the design, fabrication, and testing of fire dampers was Underwriters Laboratories, Inc. (UL) Standard 555, "Fire Dampers and Ceiling Dampers." The standard does not evaluate whether or not fire dampers will close under air flow conditions. Therefore, the UL fire damper rating only indicates whether a fire damper in the closed position will maintain its integrity under fire conditions for a specific time period.

Fire damper testing methods that do not simulate the actual total differential pressure at the damper (i.e., visual inspection or drop testing with duct access panels open) may not show operability under air flow conditions. Fire damper surveillance testing should model air flow to ensure that the dampers will close fully when called upon to do so. This can be addressed by (1)

type testing "worst-case" air flow conditions of plant-specific fire damper configurations, (2) testing under air flow conditions all dampers installed in required fire barriers, or (3) administratively shutting down the ventilation systems to an area upon confirmation of a fire. The last approach should be incorporated into plant emergency procedures.

4.2.1.4 Penetration Seals. Openings through fire barriers for pipe, conduit, and cable trays that separate fire areas should be sealed or closed to provide a fire resistance rating at least equal to that required of the barrier itself. Openings inside conduit larger than 102 mm (4 inches) in diameter should be sealed at the fire barrier penetration. Openings inside conduit 102 mm (4 inches) or less in diameter should be sealed at the fire barrier unless the conduit extends at least 1.5 m (5 feet) on each side of the fire barrier and is sealed either at both ends or at the fire barrier with material to prevent the passage of smoke and hot gases. Fire barrier penetrations that maintain environmental isolation or pressure differentials should be qualified by test to maintain the barrier integrity under such conditions.

Penetration seals should be installed by qualified individuals, and appropriate quality assurance/quality control methods should be in force during installation. As part of the installation process, penetration seals should be inspected to ensure that the seal does not contain voids, gaps, and splits.

4.2.1.5 Testing and Qualification

a. Structural Fire Barriers

The design adequacy of fire barrier walls, floors, ceilings, and enclosures should be verified by fire endurance testing. NRC fire protection guidance refers to the guidance of NFPA 251 and ASTM E-119, "Standard Test Methods for Fire Tests of Building Construction and Materials," as acceptable test methods for demonstrating fire endurance performance. The guidance of NFPA 251 and ASTM E-119 should be consulted with regard to construction, materials, workmanship, and details such as dimensions of parts and the size of the specimens to be tested. In addition, NFPA 251 and ASTM E-119 should be consulted with regard to the placement of thermocouples on the specimen.

The fire endurance test acceptance criteria for wall, floor, ceiling, and enclosure fire barriers are:

- The fire barrier design has withstood the fire endurance test without the passage of flame or the ignition of cotton waste on the unexposed side for a period of time equivalent to the fire resistance rating required of the barrier;

- The temperature levels recorded on the unexposed side of the fire barrier are analyzed and demonstrable that the maximum temperature does not exceed 139°C [250°F] above ambient; and

- The fire barrier remains intact and does not allow projection of water beyond the unexposed surface during the hose stream test.

If the above criteria are met for fire barrier walls, floors, ceilings, and free standing equipment enclosures separating safe shutdown functions within the same fire area, the barrier is acceptable.

b. Penetration Fire Barriers

Penetration fire barriers should be qualified by tests conducted by an independent testing authority in accordance with the provisions of NFPA 251 and ASTM E-119, "Standard Test Methods for Fire Tests of Building Construction and Materials." In addition, ASTM E-814, "Standard Test Method for Fire Tests of Through-Penetration Fire Stops," or IEEE Standard 634, "Standard Cable Penetration Fire Stop Qualification Test," could be used in development of a standard fire test.

The acceptance criteria for the test are:

- The fire barrier design has withstood the fire endurance test without passage of flame or the ignition of cables on the unexposed side for a period of time equivalent to the fire resistance rating required of the barrier.

- The temperature levels recorded for the unexposed side of the fire barrier are analyzed and demonstrate that the maximum temperature does not exceed 181°C (325°F) or 139°C (250°F) above ambient. Higher temperatures at through penetrations may be permitted when justified in terms of cable insulation ignitability.

- The fire barrier remains intact and does not allow projection of water beyond the unexposed surface during the hose stream test. The stream should be delivered through a 38 mm (1-1/2-inch) nozzle set at a discharge angle of 30% with a nozzle pressure of 517 kPa (75 psi) and a minimum discharge of 284 L/m (75 gpm) with the tip of the nozzle a maximum of 1.5 m (5 ft) from the exposed face; or the stream should be delivered through a 38 mm (1-1/2-inch) nozzle set at a discharge angle of 15% with a nozzle pressure of 517 kPa (75 psi) and a minimum discharge of 284 L/m (75 gpm) with the tip of the nozzle a maximum of 3 m (10 ft) from the exposed face; or the stream should be delivered through a 64 mm (2-1/2-inch) national standard playpipe equipped with 29 mm (1-1/8-inch) tip, nozzle pressure of 207 kPa (30 psi), located 6.1 m (20 ft) from the exposed face.

The construction and installation techniques for door and ventilation openings and other penetrations through fire barriers should be qualified by fire endurance tests. The test specimen should be truly representative of the construction for which classification is desired as to materials, workmanship, and details such as dimensions of parts, and should be built under conditions representative of those obtaining as practically applied in building construction and operation. The physical properties of the materials and ingredients used in the test specimen should be determined and recorded.

In view of the large number of possible penetration seal configurations, it may not be practical to test every penetration configuration. The following section provides

guidance on evaluation of penetration seal designs against results of limited fire test programs.

4.2.1.6 Evaluation of Penetration Seal Designs with Limited Testing. The results of fire test programs that include a limited selection of test specimens that have been specifically designed to encompass or bound the entire population of in-plant penetration seal configurations may be acceptable. In such cases, the engineering evaluation performed to justify the seal designs should consider the following.

a. Size of sealed opening — In some cases, a successful fire endurance test of a particular fire barrier penetration seal configuration for a particular size opening may be used to justify the same configuration for smaller openings.

b. Penetrating items — A satisfactory test of a seal configuration that contains a particular pattern of penetrating items can be used to qualify variations on the tested pattern. Variations that are acceptable include eliminating or repositioning one or more of the penetrating items, reducing the size (cross-sectional area) of a particular penetrating item, or increasing the spacing between penetrating items. However, since penetrating items provide structural support to the seal, the free area of the seal material and the dimensions of the largest free span may also be factors that affect the fire-resistive performance of the seal assembly. The thickness of the seal material needed to obtain a particular fire rating may also be a function of the free area or the distance between the penetrating items and the outside edge of the seal assembly. In other cases, consideration of the penetrating items takes on special performance because of the heat sink they provide.

c. Cable type and fill — A satisfactory test of a seal configuration with certain electrical penetrations containing a specified fill ratio and cable type can be used to qualify similar configurations containing the same or a smaller cable fill ratio and the same cable jacket material or a less combustible jacket material. The thermal conductivity of the penetrating cables is also important.

d. Damming materials — The fire resistive performance of a given seal configuration can be improved if a fire-resistant damming material covers one or both surfaces of the seal. A satisfactory test of a seal configuration without a permanent fire-resistant dam can be used to qualify the same configuration with a permanent fire-resistant dam, all other seal attributes being equal. The converse is not true.

e. Configuration orientation — A satisfactory test of a particular seal configuration in the horizontal orientation (with the test fire below the seal) can be used to qualify the same configuration in a vertical orientation if the symmetry of the design configurations are comparable. For example, if a non-symmetric penetration seal configuration (e.g., a seal with a damming board on the bottom, but not on the top) is qualified for a floor-ceiling orientation with the damming board on the fire side of the test specimen, the configuration could only be qualified for a wall orientation if a damming board was installed on both sides of the seal or if the potential fire hazard is limited to the side with the damming board.

f. Material type and thickness — Satisfactory testing of a particular seal configuration with a specific seal material thickness can be used to qualify the same configuration with a greater seal material thickness of the same type of seal material. The converse is not true.

g. Type testing — In cases in which a single test of a particular seal configuration is to serve as a qualification test for the same or similar design configurations with different design parameters, the tested configuration should be the worst-case design configuration with the worst-case combination of design parameters. This would test and qualify a condition that would fail first, if failure occurs at all. Successful testing of the worst-case condition can then serve to qualify the same or similar design configurations for design parameters within the test range. It would be appropriate to conduct multiple tests to assess a range of design parameters.

The guidance in Regulatory Position 4.2.1 is based on Appendix R to 10 CFR Part 50, CMEB 9.5-1, NUREG-1552, Supplement 1 to NUREG 1552, GL 86-10, Supplement 1 to GL 86-10, IN 83-69, IN 88-04, IN 88-56, and IN 89-52.

4.2.2 Structural Steel Protection. Structural steel forming a part of or supporting fire barriers should be protected to provide fire resistance equivalent to that required of the barrier. Where the structural steel is not protected and has a lower fire rating than the required rating of the fire barrier, the configuration should be justified by a fire hazards analysis that shows the temperature the steel will reach during fire and the ability of the steel to carry the required loads at that temperature. The need to protect structural steel that forms a part of or supports fire barriers is consistent with sound fire protection engineering principles as delineated in NFPA codes and standards and the NFPA Fire Protection Handbook.

Structural steel whose sole purpose is to carry dynamic loads from a seismic event need not be protected solely to meet fire barrier requirements, unless the failure of any structural steel member owing to a fire could result in significant degradation of the fire barrier.

The guidance in Regulatory Position 4.2.2 is based on CMEB 9.5-1, GL 88-33, and GL 86-10.

4.2.3 Fire Resistive Protection for Electrical Circuits

4.2.3.1 Electrical Raceway Fire Barrier Systems. Redundant cable systems important to safety should be separated from each other and from potential fire exposure hazards in non-safety-related areas in accordance with the separation means of Regulatory Position 5.5.a-c. For areas where separation of electrical circuits important to safe shutdown cannot be accomplished via rated structural fire barriers, cable protection assemblies have been applied to conduit and cable trays to meet 1-hour and 3-hour separation requirements.

The design of fire barriers for horizontal and vertical cable trays should meet the requirements of ASTM E119, including a hose stream test. The acceptance criteria for raceway fire barriers is discussed in Regulatory Position 4.3.2 to this guide.

4.2.3.2 Fire Rated Cables. Licensees should request an exemption or deviation, as appropriate, when relying on fire rated cables to meet NRC requirements for protection of safe shutdown systems or components from the affects of fire. (See Regulatory Position 1.8.)

4.2.3.3 Fire Stops for Cable Routing. Fire stops should be installed every 6.1 m (20 feet) along horizontal cable routings in areas important to safety 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 mid-height if the vertical run is 6.1 m (20 feet) or more but less than 9.1 m (30 feet) or at 4.6 m (15-foot) intervals in vertical runs of 9.1 m (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 30 minutes when tested for the largest number of cable routings and maximum cable density.

4.3 Testing and Qualification of Electrical Raceway Fire Barrier Systems

4.3.1 Electrical Raceway Fire Barrier Systems: General Guidelines

Fire barriers relied upon to protect shutdown-related systems and to meet the separation means of Regulatory Position 5.5 should have a fire rating of either 1 or 3 hours. Fire rating is defined as the endurance period of a fire barrier or structure; it defines the period of resistance to a standard fire exposure before the first critical point in behavior is observed.

Fire endurance ratings of building construction and materials are demonstrated by testing fire barrier assemblies in accordance with the provisions of the applicable sections of NFPA 251 and ASTM E-119. Assemblies that pass specified acceptance criteria (e.g., standard time-temperature fire endurance exposure, unexposed side temperature rise, and hose stream impingement) are considered to have a specific fire resistance rating.

The basic premise of the fire resistance criteria is that fire barriers that do not exceed 181°C [325°F] cold side temperature(3) and pass the hose stream test provide reasonable assurance that the shutdown capability is protected without further analyses. If the temperature criterion is exceeded, sufficient additional information is needed to perform an engineering evaluation to demonstrate that the shutdown capability is protected.

4.3.2 Fire Endurance Test Acceptance Criteria for Electrical Raceway and Component Fire Barrier Systems for Separating Safe Shutdown Functions Within the Same Fire Area

The fire endurance qualification test for fire barrier materials applied directly to a raceway or component is considered to be successful if all three of the following conditions are met.

1. The average unexposed side temperature of the fire barrier system, as measured on the exterior surface of the raceway or component, did not exceed 139°C [250°F] above its initial temperature; and

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

(NFPA 251 and ASTM E-119 allow this temperature to be determined by averaging thermocouple temperature readings. For the purposes of this criterion, thermocouple averaging can be used provided similar series of thermocouples (e.g., cable tray side rail) are averaged together to determine temperature performance of the raceway fire barrier system. In addition, conditions of acceptance are placed on the temperatures measured by a single thermocouple. If any single thermocouple exceeds 30 percent of the maximum allowable temperature rise (i.e., 139°C + 42°C = 181°C [250°F + 75°F = 325°F]), the test exceeded the temperature criteria limit.)

2. Irrespective of the unexposed side temperature rise during the fire test, if cables or components are included in the fire barrier test specimen, a visual inspection is performed.(4) Cables should not show signs of degraded conditions(5) resulting from the thermal effects of the fire exposure; and

   (When signs of thermal degradation are present, the fire barrier did not perform its intended fire-resistive function. For barriers that are not capable of performing their intended function, an engineering analysis that demonstrates that the functionality of thermally degraded cables or components was maintained and that the cables or components would have adequately performed their intended function during and after a postulated fire exposure should be performed. A methodology for demonstrating the functionality of cables during and after a fire test exposure is provided below. The purpose of the functionality tests is to justify observed deviations in fire barrier performance. For fire barrier test specimens that are tested without cables, an engineering analysis justifying internal fire barrier temperature conditions greater than allowed can be based on a comparison of the fire barrier internal temperature profile measured during the fire endurance test to existing cable specific performance data, such as environmental qualification (EQ) tests.)

3. The cable tray, raceway, or component fire barrier system remained intact during the fire exposure and water hose stream test without developing any openings through which the cable tray, raceway, or component (e.g., cables) is visible. (See Regulatory Position 4.3.3 regarding acceptable hose stream test methods.)

The test specimen should be representative of the construction for which the fire rating is desired as to materials, workmanship, and details such as dimensions of parts, and should be built under representative conditions. Raceway fire barrier systems being subjected to qualification fire endurance tests should be representative of the end use. For example, if it is intended to install a cable tray fire barrier system in the plant without protecting the cable tray supports, the test program should duplicate these field conditions. In addition, the fire test program should encompass or bound raceway sizes and the various configurations for those fire barrier systems

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

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

installed in the plant. It should be noted that several test specimens will be required in order to qualify various sizes of horizontal and vertical runs of cable trays and conduits, junction boxes and pull boxes, etc. The cable tray or raceway design used for the tests should be constructed with materials and configurations representative of in-plant conditions (e.g., the mass associated with typical steel conduits and cable trays, representative internal and external penetration seals). If cables are included in the raceway fire barrier test specimen, these cables should be representative of the installed plant-specific cables.

Measuring cable temperatures is not a reliable means for determining excessive temperature conditions that may occur at any point along the length of the cable during the fire test. In lieu of measuring the unexposed surface temperature of the fire barrier test specimen, methods that will measure the surface temperature of the raceway (e.g., exterior of the conduit, side rails of cable trays, bottom and top of cable tray surfaces, junction box external surfaces) can be considered as equivalent if the raceway components used to construct the fire test specimen represent plant-specific components and configurations. The metal surfaces of the raceway, under fire test conditions, exhibit good thermal conductivity properties. Temperatures measured on these surfaces provide an indication of the actual temperature rise within the fire barrier system.

In 1979, American Nuclear Insurers (ANI) issued a fire endurance test method for raceway fire barrier systems for insurance purposes. This method, "Fire Endurance Protective Envelope Systems for Class 1E Electrical Circuits" (ANI Test), specified that cable temperatures be monitored by thermocouples. Since cable jackets have a low thermal conductivity, the actual local temperatures of the cable jackets' indications of barrier failure and internal fire barrier temperature rise conditions during the fire exposure are masked. Monitoring cable temperatures can give indications of low internal fire barrier temperature conditions during the fire endurance test. Using this temperature monitoring approach, cable damage can occur without indication of excessive temperatures on the cables. This, linked with no loss of circuit integrity, would give indications of a successful test. The staff considers monitoring the cable temperature as the primary means of determining cable tray or raceway fire barrier performance to be nonconservative. Therefore, the staff has incorporated the provision for a post-fire visual inspection of cables that are installed in fire barrier test specimens. As discussed above, temperatures monitored on the exterior surface of the raceway provide a more representative indication of fire barrier performance.

Fire endurance tests of raceway fire barrier systems should be without cables. This method is preferred because by excluding cables from the test specimen it eliminates bias in the test results created by the thermal mass of the cables. Without this thermal mass, the internal temperature conditions measured by the test specimen thermocouples during the fire exposure will provide a more accurate determination of fire barrier thermal performance.

4.3.2.1 Thermocouple Placement — Test Specimens Containing Cables. The following are acceptable placements of thermocouples for determining the thermal performance of raceway or cable tray fire barrier systems that contain cables during the fire exposure.

a. **Conduits —** The temperature rise on the unexposed surface of a fire barrier system installed on a conduit should be measured by placing the thermocouples every 152 mm [6

inches][6] on the exterior conduit surface underneath the fire barrier material. The thermocouples should be attached to the exterior conduit surface located opposite the test deck and closest to the furnace fire source. Thermocouples should also be placed immediately adjacent to all structural members, supports, and barrier penetrations.

b. **Cable Trays —** The temperature rise on the unexposed surface of a fire barrier system installed on a cable tray should be measured by placing the thermocouples on the exterior surface of the tray side rails between the cable tray side rail and the fire barrier material. In addition to placing thermocouples on the side rails, thermocouples should be attached to two AWG 8 stranded bare copper conductors. The first copper conductor should be installed on the bottom of the cable tray rungs along the entire length and down the longitudinal center of the cable tray run. The second conductor should be installed along the outer top surface of the cables closest to the top and toward the center of the fire barrier. Thermocouples should be placed every 152 mm (6 inches) down the longitudinal center along the outside surface of the cable tray side rails and along the bare copper conductors. Thermocouples should also be placed immediately adjacent to all structural members, supports, and barrier penetrations.

c. **Junction Boxes (JBs) —** The temperature rise on the unexposed surface of a fire barrier system installed on junction boxes should be measured by placing thermocouples on either the inside or the outside of each JB surface. Each JB surface or face should have a minimum of one thermocouple, located at its geometric center. In addition, one thermocouple should be installed for every one square foot of JB surface area. These thermocouples should be located at the geometric centers of the one square foot areas. At least one thermocouple should also be placed within 25 mm (1 inch) of each penetration connector/interface.

d. **Airdrops —** The internal airdrop temperatures should be measured by thermocouples placed every 305 mm (12 inches) on the cables routed within the air drop and by a stranded AWG 8 bare copper conductor routed inside and along the entire length of the airdrop system with thermocouples installed every 152 mm (6 inches) along the length of the copper conductor. The copper conductor should be in close proximity with the unexposed surface of the fire barrier material. Thermocouples should also be placed immediately adjacent to all supports and barrier penetrations.

4.3.2.2 Thermocouple Placement -- Test Specimens Without Cables. The following are acceptable thermocouple placements for determining the thermal performance of raceway or cable tray fire barrier systems that do not contain cables.

a. **Conduits —** The temperature rise of the unexposed surface of a fire barrier system installed on a conduit should be measured by placing thermocouples every 152 mm [6 inches] on the exterior conduit surface between the conduit and the unexposed surface of the fire barrier material. These thermocouples should be attached to the exterior conduit surface opposite the test deck and closest to the furnace fire source. The internal raceway temperatures should be measured

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

by a stranded AWG 8 bare copper conductor routed through the entire length of the conduit system with thermocouples installed every 152 mm [6 inches] along the length of the copper conductor. Thermocouples should also be placed immediately adjacent to all structural members, supports, and barrier penetrations.

b. Cable Trays — The temperature rise on the unexposed surface of a fire barrier system installed on a cable tray should be measured by placing thermocouples every 152 mm [6 inches] on the exterior surface of each tray side rails between the side rail and the fire barrier material. Internal raceway temperatures should be measured by a stranded AWG 8 bare copper conductor routed on the top of the cable tray rungs along the entire length and down the longitudinal center of the cable tray run with thermocouples installed every 152 mm [6 inches] along the length of the copper conductor. Thermocouples should be placed immediately adjacent to all structural members, supports, and barrier penetrations.

c. Junction Boxes — The temperature rise on the unexposed surface of a fire barrier system installed on junction boxes (JBs) should be measured by placing thermocouples on either the inside or the outside of each JB surface. Each JB surface or face should have a minimum of one thermocouple, located at its geometric center. In addition, one thermocouple should be installed for every one square foot of JB surface area. These thermocouples should be located at the geometric centers of the one square foot areas. At least one thermocouple should also be placed within 25 mm [1 inch] of each penetration connector/interface.

d. Airdrops — The internal airdrop temperatures should be measured by a stranded AWG 8 bare copper conductor routed inside and along the entire length of the airdrop system with thermocouples installed every 152 mm [6 inches] along the length of the copper conductor. The copper conductor should be in close proximity with the unexposed surface of the fire barrier material. Thermocouples should also be placed immediately adjacent to all supports and penetrations.

4.3.2.3 Criteria for Averaging Temperatures. Temperature conditions on the unexposed surfaces of the fire barrier material during the fire test will be determined by averaging the temperatures measured by the thermocouples installed in or on the raceway. In determining these temperature conditions, the thermocouples measuring similar areas of the fire barrier should be averaged together. Acceptance will be based on the individual averages. The following methods of averaging should be followed.

a. Conduits — The thermocouples applied to the outside metal surface of the conduit should be averaged together.

b. Cable Trays — The thermocouples on each cable tray side rail should be averaged separately. For example, thermocouples placed on one side rail will be averaged separately from the other side rail. In addition, the temperature conditions measured by thermocouples on the bare copper conductor should be averaged separately from the side rails.

c. Junction Boxes — For JBs that have only one thermocouple on each JB surface, the individual JB surface thermocouples should be averaged together. For JBs that have more than

one thermocouple on each JB surface, the thermocouples on the individual JB surfaces should be averaged together.

d. **Airdrops —** The thermocouples placed on the copper conductor within the airdrop fire barrier should be averaged together.

The average of any thermocouple group should not exceed 139°C [250°F] above the unexposed side temperature within the fire barrier test specimen at the onset of the fire endurance test. In addition, the temperature of each individual thermocouple will be evaluated. Individual thermocouple conditions should not exceed the 139°C [250°F] temperature rise by more than 30 percent (i.e., 181°C [375°F]).

If a fire barrier test specimen without cables does not meet the average or maximum single point temperature criteria, the internal raceway temperature profile as measured by the instrumented bare copper conductors during the fire exposure can be used to assess cable functionality through air oven tests of plant specific cable types and construction, as discussed below.

4.3.3 Hose Stream Tests

NFPA 251 and ASTM E-119 allow flexibility in hose stream testing. The standards allow the hose stream test to be performed on a duplicate test specimen subjected to a fire endurance test for a period equal to one-half of that indicated as the fire resistance rating, but not for more than 1 hour (e.g., 30-minute fire exposure to qualify a 1-hour fire rated barrier).

For safe shutdown-related fire barrier systems and duplicate electrical cable tray or raceway and component fire barrier test specimens that have been exposed to the ½-duration test fire exposure, the staff finds the hose stream application specified by NFPA 251 acceptable. NFPA 251 requires the stream of water to be delivered through a 64-mm [2½-inch] hose discharging through a standard 29-mm [1½-inch] playpipe nozzle onto the test specimen after the fire exposure test. The stream is applied with the nozzle orifice positioned 6.1 meters [20 feet] away from the center of the test specimen at a pressure of 207 kPa [30 psi]. The application of the stream is to all exposed parts of the specimen for a duration of at least 1 minute for a 1-hour barrier and 2½ minutes for a 3-hour barrier.

As an alternative for electrical raceway fire barrier test specimens, the application of the hose stream test can be performed immediately after the completion of the full fire endurance test period. If this method is used to satisfy the hose stream test criteria, any one of the following hose stream applications is acceptable.

- The stream applied at random to all exposed surfaces of the test specimen through a 64-mm [2½-inch] national standard playpipe with a 29-mm [1½- inch] orifice at a pressure of 207 kPa [30 psi] at a distance of 6.1 meters [20 feet] from the specimen. (Durations of the hose stream applications — 1 minute for a 1-hour barrier and 2½ minutes for a 3-hour barrier.) or

- The stream applied at random to all exposed surfaces of the test specimen through a 38-mm [1½-inch] fog nozzle set at a discharge angle of 30 degrees with a nozzle pressure of 517 kPa [75 psi] and a minimum discharge of 284 lpm [75 gpm] with the tip of the nozzle at a maximum of 1.5 meters [5 feet] from the test specimen. (Duration of the hose stream application — 5 minutes for both 1-hour and 3-hour barriers.) or

- The stream applied at random to all exposed surfaces of the test specimen through a 38-mm [1½-inch] fog nozzle set at a discharge angle of 15 degrees with a nozzle pressure of 517 kPa [75 psi] and a minimum discharge of 284 lpm [75 gpm] with the tip of the nozzle at a maximum of 3 meters [10 feet] from the test specimen. (Duration of the hose stream application — 5 minutes for both 1-hour and 3-hour barriers.)

4.3.4 Demonstrating Functionality of Cables Protected by Raceway Fire Barrier Systems During and After Fire Endurance Test Exposure

During fire tests of raceway fire barrier systems, thermal damage to the cables has led to cable jacket and insulation degradation without the loss of circuit integrity as monitored using ANI criteria (applied voltage of 8 to 10 volts dc). Since cable voltages used for ANI circuit integrity tests do not replicate cable operating voltages, loss of cable insulation conditions can exist during the fire test without a dead short occurring. It is expected that if the cables were at rated power and current, a fault would propagate. The use of circuit integrity monitoring during the fire endurance test is not a valid method for demonstrating that the protected shutdown circuits are capable of performing their required function during and after the test fire exposure. Therefore, circuit integrity monitoring using the ANI criteria is not required to satisfy NRC acceptance criteria for fire barrier qualification. The following approaches are acceptable for evaluation of cable functionality.

4.3.4.1 Use of Environmental Qualification Data. Comparison of the fire barrier internal time-temperature profile measured during the fire endurance test to existing cable performance data, such as data from environmental qualification (EQ) tests, could be proposed to the staff as a method for demonstrating cable functionality. EQ testing is typically performed to rigorous conditions, including rated voltage and current. By correlating the EQ test time-temperature profile to the fire test time-temperature profile, the EQ test data would provide a viable mechanism to ensure cable functionality. A large body of EQ test data for many cable types exists today. The use of EQ data represents a cost-effective approach for addressing cable functionality for fire tests for those cases where the 181°C [325°F] limit is exceeded. A comparison of fire test temperature profiles to existing EQ and loss-of-coolant accident (LOCA) test results or air oven test results is an acceptable approach to demonstrate cable functionality provided the subject analysis incorporates the anticipated temperature rise that is due to self heating effects of installed power cables with the fire test results.

4.3.4.2 Cable Insulation Tests. The two principal materials used as cable insulation and cable jackets by the nuclear industry are thermoplastics and thermosetting polymeric materials. A thermoplastic material can be softened and re-softened by heating and reheating. Conversely, thermosetting cable insulation materials cure by chemical reaction and do not soften when heated. Under excessive heating thermosetting insulation becomes stiff and brittle. Electrical faults may be caused by softening and flowing of thermoplastic insulating materials at temperatures as low as

149°C [300°F]. Thermosetting electrical conductor insulation materials usually retain their electrical properties under short-term exposures to temperatures as high as 260°C [500°F]. Insulation resistance (Megger) tests provide indications of the condition of the cable insulation resistance, whereas the high potential (Hi-Pot) test provides assurance that the cable has sufficient dielectric strength to withstand the applied rated voltage. A cable insulation failure usually results from two breakdown modes: One failure mode is excessive dielectric loss that is due to low insulation resistance, and the other failure mode is overpotential stress that is due to loss of dielectric strength of the insulation material.

To provide reasonable assurance that the cables would have functioned during and after the fire exposure, Megger tests need to be performed before the fire test, at multiple time intervals during the fire exposure (i.e., every 20 minutes during the 1-hour fire test and every hour during the 3-hour fire test) for instrumentation cables only, and immediately after the fire endurance test to assess the cable insulation resistance levels. This testing will assure that the cables will maintain the insulation resistance levels necessary for proper operation of instruments.

The Megger tests (pre-fire, during the fire [if performed], and immediately after the fire test conditions) should be done conductor-to-conductor for multi-conductor and conductor-to-ground for all cables. The minimum acceptable insulation resistance (IR) value, using the test voltage values as shown in the table below, is determined by using the following expression:

$$\text{IR (Mega-ohms)} = \{[K+1 \text{ Mega-ohm}] * 1000 \text{ (ft)}\} / \text{Length (ft)}$$

Where K = 1 Mega-ohm/KV * Operating Voltage (expressed in KV)

In addition, to determine the insulation resistance levels required for nuclear instrumentation cables, an assessment of the minimum insulation resistance value (e.g., one mega-ohm) and its potential impact on the functionality of these cables should be evaluated. An ac or dc high potential (Hi-Pot) test for power cables greater than 1000 volts (V) should also be performed after the post-fire Megger tests to assess the dielectric strength. This test provides assurance that the cable will withstand the applied voltage during and after a fire. The high potential test should be performed for a 5 minute duration at 60 percent of either 80 V/mil ac or 240 V/mil dc (e.g., 125 mil conductor insulation thickness x 240 V/mil dc x 0.6 = 18,000 V dc).

The table below summarizes the Megger and Hi-Pot test voltages[(7)] that, when applied to power, control, and instrumentation cables, would constitute an acceptable cable functionality test.

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

TYPE	OPERATING VOLTAGE	MEGGER TEST VOLTAGE	HIGH POTENTIAL TEST VOLTAGE
Power	>1000 V ac	2500 V dc	60% x 80 V/mil (ac) 60% x 240 V/mil (dc)
Power	<1000 V ac	1500 V dc[8]	None
Instrument and Control	<250 V dc <120 V ac	500 V dc	None

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

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

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

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

b. The cables being evaluated should be subjected to the Megger and high potential tests, recommended above in Regulatory Position 4.3.4.2, "Cable Insulation Tests."

c. The impact force test, which simulates the force of impact imposed on the raceway by the solid stream test, described in UL 1724, Appendix B, paragraph B3.16, is not required to be performed.

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

4.3.4.4 Cable Thermal Exposure Threshold. The following analysis, which is based on determining whether a specific insulation material will maintain electrical integrity and operability within a raceway fire barrier system during and after an external fire exposure, is an acceptable method for evaluating cable functionality. In order to determine cable functionality, it is necessary to consider the operating cable temperatures within the fire barrier system at the onset of the fire exposure and the thermal exposure threshold (TET) temperature of the cable. For example, if the TET of a specific thermoplastic cable insulation (Brand X) is 149°C [300°F] and the normal operating temperature within the fire barrier system is 66°C [150°F], the maximum temperature rise within the fire barrier system should not exceed 83°C [150°F] during exposure to an external fire of a duration equal to the required fire resistance rating of the barrier. For this example, the TET limit for Brand X cable is 83°C [150°F] above the cable operating temperatures within the fire barrier system at the onset of the external fire exposure. The cable TET limits in conjunction with a post-test visual cable inspection and the Hi-Pot test described above should readily demonstrate the functionality of the cable circuit during and after a fire.

The normal cable operating temperature can be determined by loading cable specimens installed within a thermal barrier system in the test configuration with rated voltage and current. The TET temperature limits for most cable insulation may be obtained from the manufacturer's published data, which is given as the short-circuit rating limit. With the known TET and normal operating temperature for each thermal barrier system configuration, the maximum temperature rise limit within a fire barrier system may then be determined.

The guidance in Regulatory Position 4.3.4 is based on Appendix R to 10 CFR Part 50, APCSB 9.5-1, ASB 9.5-1, CMEB 9.5-1, GL 86-10, and Supplement 1 to GL 86-10.

4.3.5 Cable Qualification

Electric cable construction should, as a minimum, pass the flame test in IEEE Standard 383 or IEEE Standard 1202. (This does not imply that cables passing either test will not require additional fire protection.) For cable installations in operating plants and plants under construction prior to July 1, 1976, that do not meet the IEEE 383 flame test requirements, the cables should be covered with an approved flame retardant coating and properly derated.

Non-qualified cable that is not covered with an approved flame retardant coating should be protected with an automatic fire suppression system.

5. SAFE SHUTDOWN CAPABILITY

When considering the consequences of a fire in a given fire area during the evaluation of safe shutdown capabilities of the plant, it should be demonstrated that one success path of equipment that can be used to bring the reactor to hot shutdown conditions in the case of BWRs, or hot standby in the case of PWRs, remains unaffected by the fire. It should also be demonstrated that fire damage to one success path of equipment needed for achieving cold shutdown will be limited so that equipment will be returned to an operating condition within 72 hours, or for areas requiring alternate, dedicated, or backup shutdown, demonstrate that cold shutdown capability can be restored and cold shutdown achieved within 72 hours.

One of the objectives of the fire protection program is to demonstrate that one success path of systems necessary to achieve and maintain hot shutdown (e.g., hot standby for a PWR, hot shutdown for a BWR) are maintained free of fire damage. The success path of safe shutdown systems should be capable of meeting Regulatory Positions 5.1 and 5.2 and performing the necessary shutdown functions. The capability of the required shutdown functions should be based on a previous analysis, if possible (e.g., those analyses in the FSAR). The equipment required for alternative or dedicated shutdown should have the same or equivalent capability as that relied on in the above-referenced analysis.

5.1 Safe Shutdown Performance Goals for Redundant Systems

Ensure that fuel integrity is maintained and that there are no adverse consequences on the reactor pressure vessel integrity or the attached piping. Fuel integrity is maintained provided the fuel design limits are not exceeded.

The guidance in Regulatory Position 5.1 is based on the Richards Letter (2000).

5.2 Alternative or Dedicated Shutdown Design and Performance Goals

5.2.1 Alternative or Dedicated Safe Shutdown System Design Goals

During the post-fire shutdown, the reactor coolant system process variables should be maintained within those predicted for a loss of normal ac power, and the fission product boundary integrity should not be affected; i.e., there should be no fuel clad damage, rupture of any primary coolant boundary, or rupture of the containment boundary.

The systems used for alternative or dedicated shutdown need not be designed to (1) seismic Category I criteria, (2) single failure criteria, or (3) other design basis accident criteria, except the portions of these systems that interface with or impact existing safety systems.

5.2.2 Safe Shutdown Performance Goals for Alternative or Dedicated Systems

The performance goals for the shutdown functions should be:

- The reactivity control function should be capable of achieving and maintaining cold shutdown reactivity conditions.

- The reactor coolant makeup function should be capable of maintaining the reactor coolant level above the top of the core for BWRs and within the level indication of the pressurizer for PWRs.

- The reactor heat removal function should be capable of achieving and maintaining decay heat removal.

- The process monitoring function should be capable of providing direct readings of the process variables necessary to perform and control the above functions.

- The supporting functions should be capable of providing the process cooling, lubrication, etc., necessary to permit the operation of the equipment used for safe shutdown functions.

The guidance for Regulatory Position 5.2 is in Appendix R to 10 CFR Part 50 and CMEB 9.5-1.

5.3 Hot Standby (PWR) Hot Shutdown (BWR) Systems and Instrumentation

One success path of equipment necessary to achieve hot standby (PWR) or hot shutdown (BWR) from either the control room or emergency control stations should be maintained free of fire damage by a single fire, including an exposure fire. Manual operation of valves, switches, and circuit breakers is allowed to operate equipment and isolate systems and is not considered a repair. Damage considerations should also include damage to equipment from the normal or inadvertent operation of fire suppression systems.

Recovery actions are allowed to systems and components not used for hot shutdown, but whose fire or fire suppressant-induced maloperations may adversely affect hot shutdown capability. These recovery actions should be achievable prior to the maloperations causing an unrecoverable plant condition.

5.3.1 PWR Systems and Instrumentation

In accordance with GL 81-12, systems and instrumentation with the following capabilities are generally necessary for achieving hot standby of PWRs.

5.3.1.1 Reactivity Control. Reactor trip capability (scram) and boration capability (e.g., charging pump, makeup pump or high-pressure injection pump taking suction from concentrated borated water supplies, as well as letdown system if required).

5.3.1.2 Reactor Coolant Makeup. Reactor coolant makeup capability, e.g., charging pumps or the high-pressure injection pumps. Power-operated relief valves may be required to reduce pressure to allow use of the high-pressure injection pumps.

5.3.1.3 Reactor Coolant System Pressure Control. Reactor pressure control capability, e.g., charging pumps or pressurizer heaters and use of the letdown systems if required.

5.3.1.4 Decay Heat Removal. Decay heat removal capability, e.g., power-operated relief valves (steam generator) or safety relief valves for heat removal with a water supply and emergency or auxiliary feedwater pumps for makeup to the steam generator. Service water or other pumps may be required to provide water for auxiliary feed pump suction if the condensate storage tank capacity is not adequate for 72 hours.

5.3.1.5 Process Monitoring Instrumentation. The following instrumentation is considered necessary to achieve hot standby for PWRs.

- Pressurizer pressure and level

- Reactor coolant cold leg temperature and core exit thermocouples or hot leg temperature
- Steam generator pressure and wide-range level
- Source-range flux monitor
- Diagnostic instrumentation for shutdown systems
- Level indication for all tanks used (e.g., CST).

5.3.1.6 Support. The equipment required to support operation of the above described shutdown equipment, e.g., instrument air, component cooling water, service water, and onsite power sources (ac, dc), and associated electrical distribution systems.

5.3.2 BWR Systems and Instrumentation

In accordance with GL 81-12, systems and instrumentation with the following capabilities are generally necessary for achieving hot shutdown of BWRs.

5.3.2.1 Reactivity Control.. Reactor trip capability (scram).

5.3.2.2 Reactor Coolant Makeup. Reactor coolant inventory makeup capability, e.g., reactor core isolation cooling system (RCIC), the high-pressure coolant injection system (HPCI), low pressure coolant injection (LPCI), and core spray.

5.3.2.3 Reactor Pressure Control and Decay Heat Removal. Depressurization system valves or safety relief valves for venting to the suppression pool. The residual heat removal system in steam condensing mode and the service water system may also be used for heat removal to the ultimate heat sink.

5.3.2.4 Suppression Pool Cooling. Residual heat removal system (in suppression pool cooling mode) service water system to maintain hot shutdown.

5.3.2.5 Process Monitoring. The following instrumentation is considered necessary to achieve hot shutdown for BWRs.

- Reactor water level and pressure,
- Suppression pool level and temperature,
- Emergency or isolation condenser level,
- Diagnostic instrumentation for shutdown systems,
- Level indication for all tanks used.

5.3.2.6 Support. The equipment required to support operation of the above described shutdown equipment, e.g., instrument air, closed loop cooling water, service water, and onsite power sources (ac and dc), and associated electrical distribution systems.

The guidance in Regulatory Position 5.3 is based on Appendix R to 10 CFR Part 50, GL 81-12, GL 86-10, and Richards Letter (2000).

5.4 Cold Shutdown Systems and Instrumentation and Allowable Repairs

For normal safe shutdown, redundant systems necessary to achieve cold shutdown may be damaged by a single fire, but damage should be limited so that at least one success path can be repaired or made operable within 72 hours using onsite capability.

For alternative or dedicated shutdown, equipment or systems that are the means to achieve and maintain cold shutdown conditions should not be damaged by fire, or the fire damage to such equipment and systems should be limited so that the systems can be made operable and cold shutdown achieved within 72 hours using only onsite power. Systems and components used for safe shutdown after 72 hours may be powered from offsite power only.

Cold shutdown capability repairs (e.g., the replacement of fuses and the replacement of cabling) are permitted. Selected equipment replacement is also allowed if practical. Procedures should be prepared for repairing damaged equipment (see Regulatory Position 5.7.3), and dedicated replacement equipment should be stored on site and controlled. Repairs should be of sufficient quality to ensure safe operation until the normal equipment is restored to an operating condition.

Repairs not permitted include the use of clip leads in control panels (i.e., hard-wired terminal lugs should be used) and the use of jumper cables other than those fastened with terminal lugs.

When repairs are necessary in the fire area, the licensee should demonstrate that sufficient time is available to allow the area to be re-entered, that expected fire and fire suppressant damage will not prevent the repairs from taking place, and that the repair procedures will not adversely impact operating systems.

5.4.1 PWR Systems and Instrumentation for Cold Shutdown

Regulatory Position 5.4.1 provides guidance on equipment and capability that is generally necessary to achieve cold shutdown, in addition to that already described in Regulatory Positions 5.3.1 and 5.3.2, to maintain hot standby (PWR) or hot shutdown (BWR).

5.4.1.1 Reactor Coolant System Pressure Reduction to Residual Heat Removal System (RHR) Capability. Reactor coolant system pressure reduction by cooldown using steam generator power operated relief valves or atmospheric dump valves.

5.4.1.2 Decay Heat Removal. Decay heat removal capability, e.g., residual heat removal system, component cooling water system, and service water system to remove heat and maintain cold shutdown.

5.4.1.3 Support. Support capability, e.g., offsite power and the associated electrical distribution system to supply the above equipment.

5.4.2 BWR Systems and Instrumentation

At this point the equipment necessary for hot shutdown has reduced the primary system pressure and temperature to the point that the RHR system may be placed in service in RHR cooling mode. Decay heat removal and associated support systems are generally needed for cold shutdown.

5.4.2.1 Decay Heat Removal. Residual heat removal system in the RHR cooling mode, service water system.

5.4.2.2 Support. Support capability, e.g., offsite power and the associated distribution systems, to provide for shutdown equipment.

The guidance in Regulatory Position 5.4 is based on Appendix R to 10 CFR Part 50, CMEB 9.5-1, GL 81-12, GL 86-10, IN 84-09, and Mattson Memo (1982).

5.5 Fire Protection of Safe Shutdown Capability

Fire barriers or automatic suppression, or both, should be installed as necessary to protect redundant systems or components necessary for safe shutdown. Except where alternative or dedicated shutdown systems are required, or where cables or equipment, including associated non-safety circuits that could prevent operation or cause maloperation due to hot shorts, open circuits, or shorts to ground of redundant success paths of systems necessary to achieve and maintain hot shutdown conditions are located within the same fire area outside of primary containment, one of the following means of ensuring that one of the success paths (of equipment for hot shutdown) is free of fire damage should be provided.

a. Separation of cables and equipment and associated non-safety circuits by a fire barrier having a 3-hour rating. Structural steel forming part of or supporting the fire barrier should be protected to provide fire resistance equivalent to that of the barrier.

b. Separation of cables and equipment and associated non-safety circuits of redundant success paths by a horizontal distance of more than 6.1 m (20 feet) with no intervening combustible or fire hazards. In addition, fire detectors and an automatic fire suppression system should be installed in the fire area.

   Insulation of electrical cables, including those with fire resistive coatings, should be considered as intervening combustibles in other than negligible quantities (i.e., isolated cable runs) as determined by engineering and fire hazard analysis. Cables in conduit are not considered intervening combustibles.

c. Enclosure of cable and equipment and associated circuits in a fire barrier having a 1-hour rating. In addition, fire detectors and an automatic fire suppression system should be installed in the fire area.

In meeting the provisions of Items b and c above, the installation of fire suppression and detection in a fire area should be sufficient to protect against the hazards of the area. In this regard,

detection and suppression providing less than full area coverage may be evaluated as adequate to comply with the regulation (see Regulatory Position 1.8.3).

Inside non-inerted containments, fire protection should be provided that is in accordance with the criteria above, or as specified in Regulatory Position 6.1.1.1 of this guide.

The guidance in Regulatory Position 5.5 is in Appendix R to 10 CFR Part 50, CMEB 9.5-1, GL 83-33, GL 86-10, and IN 84-09.

5.5.1 Associated Circuits of Concern

Any (associated) non-safety or safety circuits in a fire area that could adversely affect the identified shutdown equipment by feeding back potentially disabling conditions (e.g., hot shorts or shorts to ground) to power supplies or control circuits of that equipment should be evaluated. Such disabling conditions should be prevented to provide assurance that the identified safe shutdown equipment will function as designed.

Circuits within a fire area may be subject to fire damage that can affect or prevent post-fire safe shutdown capability. Associated circuits of concern are defined as those cables (safety-related, non-safety-related Class 1E and non-Class 1E) that have a physical separation less than that specified in a through c of Regulatory Position 5.5 and have one of the following.

a. A common power source with the shutdown equipment (redundant or alternative) and the power source is not electrically protected from the circuit of concern by coordinated breakers, fuses, or similar devices.

b. A connection to circuits of equipment whose spurious operation would adversely affect the shutdown capability (e.g., RHR/RCS isolation valves, ADS valves, PORVs, steam generator atmospheric dump valves, instrumentation, steam bypass).

   For consideration of spurious actuations, all possible functional failure states should be evaluated, that is, the component could be energized or de-energized by one or more circuit failure modes (i.e., hot shorts, open circuits, and shorts to ground). Therefore, valves could fail open or closed; pumps could fail running or not running; electrical distribution breakers could fail open or closed. For three-phase ac circuits, the probability of getting a hot short on all three phases in the proper sequence to cause spurious operation of a motor is considered sufficiently low as to not require evaluation except for any cases involving Hi/Lo pressure interfaces. For ungrounded dc circuits, if it can be shown that only two hot shorts of the proper polarity without grounding could cause spurious operation, no further evaluation is necessary except for any cases involving Hi/Lo pressure interfaces. However, two proper polarity faults in ungrounded multi-conductor dc circuits should be considered.

   Hot short conditions are assumed to exist until action has been taken to isolate the circuit from the fire area, or other actions as appropriate have been taken to negate the effects of the spurious actuation.

c. A common enclosure (e.g., raceway, panel, junction) with the shutdown cables (redundant or alternative) (1) that is not electrically protected by circuit breakers, fuses, or similar devices or (2) will allow propagation of the fire into the common enclosure.

The guidance in Regulatory Position 5.5.1 is based on GL 81-12, GL 86-10, and Holahan Memo (1990).

5.5.2 Identification and Evaluation of Associated Circuits of Concern

It is recognized that there are different approaches that may be used to reach the same objective of determining the interaction of associated circuits with shutdown systems. One approach is to start with the fire area, identify what is in the fire area, and determine the interaction between what is in the fire area and the shutdown systems that are outside the fire area. This approach has been designated the "Fire Area Approach." A second approach, designated the "Systems Approach," would be to identify the shutdown systems outside a fire area and then determine those circuits that are located in the fire area and that are associated with the shutdown system.

High impedance faults should be considered for all associated circuits located in the fire area of concern. Thus, simultaneous high impedance faults (below the trip point for the breaker on each individual circuit) for all associated circuits located in the fire area should be considered in the evaluation of the safe shutdown capability. Clearing such faults on associated circuits that may affect safe shutdown may be accomplished by manual breaker trips governed by written procedures. Circuit coordination studies need not be performed if it is assumed that shutdown capability will be disabled by such high impedance faults and appropriate written procedures for clearing them are provided.

5.5.2.1 Fire Area Approach.

a. For each fire area, identify (1) the power cables that connect to the same power supply of the alternative, dedicated, or backup shutdown system and the function of each power cable, (2) the cables that are considered for possible spurious operation that could adversely affect safe shutdown and the function of each cable, and (3) the cables that share a common enclosure with circuits of the alternative or dedicated shutdown systems and the function of each cable.

b. Demonstrate that fire-induced failures (e.g., hot shorts, open circuits, or shorts to ground) of each of the cables identified above will not prevent operation or cause maloperation of the alternative or dedicated shutdown method.

c. For each cable where electrical isolation has been provided, drawings should be developed that illustrate how electrical isolation is accomplished.

5.5.2.2 Systems Approach.

a. Develop a methodology to assess the potential of associated circuits that adversely affect the alternative or dedicated shutdown systems. The methodology should provide for identification of circuits that share a common power supply or common enclosure with the alternative or dedicated shutdown system and the circuits whose spurious operation would

affect shutdown. Additionally, the method for determining whether these circuits are associated circuits of concern for the fire area should be included.

b. Identify the associated circuits of concern in the fire area and demonstrate that fire-induced failures (e.g., hot shorts, open circuits, or shorts to ground) of each of the cables will not prevent operation or cause maloperation of the alternative or dedicated shutdown method.

c. For each cable where electrical isolation has been provided, drawings should be developed that illustrate how electrical isolation is accomplished.

The guidance in Regulatory Position 5.5.2 is based on GL 81-12 and GL 86-10.

5.5.3 Hi/Low Pressure Interface

For either approach described in Regulatory Position 5.5.2.1 or 5.5.2.2, an evaluation of Hi/Low pressure interfaces should be performed. Circuits associated with Hi/Low pressure interfaces should be evaluated for the potential to adversely affect safe shutdown. For example, the residual heat removal system is generally a low-pressure system that interfaces with the high-pressure primary coolant system. Thus, the interface most likely consists of two redundant and independent motor-operated valves. These two motor-operated valves and their associated cables may be subject to damage from a single fire. This single fire could cause the two valves to spuriously open, resulting in an interfacing system LOCA through the subject Hi/Low pressure system interface. To ensure that this interface and other Hi/Low pressure interfaces are adequately protected from the effects of a single fire, the following should be performed.

a. Identify each Hi/Low pressure interface that uses redundant electrically controlled devices (such as two series motor operated valves) to isolate or preclude rupture of any primary coolant boundary.

b. For each set of redundant valves identified in this Regulatory Position 5.5.3, verify that the redundant cabling (power and control) have adequate physical separation as stated by Regulatory Position 5.5 of this guide.

c. For each case where adequate separation is not provided, demonstrate that fire-induced failures (hot shorts, open circuits, and shorts to ground) of the cables will not cause maloperation and result in an interfacing systems LOCA.

The guidance in Regulatory Position 5.5.3 is based on GL 81-12.

5.5.4 Protection of Associated Circuits of Concern

The shutdown capability may be protected from the adverse effect of damage to associated circuits of concern by the separation and protection guidelines of Regulatory Position 5.5 of this guide, or alternatively by the following methods as applied to each type of associated circuit.

5.5.4.1 Common Power Source. Provide load fuse/breaker (i.e., interrupting devices) to feeder fuse/breaker coordination to prevent loss of the redundant or alternative shutdown power source. IEEE Standard 242, "IEEE Recommended Practices for Protection and Coordination of

Industrial and Commercial Power Systems," provides detailed guidance on achieving proper coordination.

To ensure that the coordination criteria are met, the following should apply:

- The associated circuit of concern interrupting devices (breakers or fuses) time-overcurrent trip characteristic for all circuit faults should cause the interrupting device to interrupt the fault current prior to initiation of a trip of any upstream interrupting device that will cause a loss of the common power source.

- The power source should supply the necessary fault current for sufficient time to ensure the proper coordination without loss of function of the shutdown loads.

The acceptability of a particular interrupting device is considered demonstrated if the following criteria are met:

- The interrupting device design should be factory tested to verify overcurrent protection as designed in accordance with the applicable UL, ANSI, or NEMA standards.

- For low and medium voltage switchgear (480V and above), circuit breaker/protective relay periodic testing should demonstrate that the overall coordination scheme remains within the limits specified in the design criteria. This testing may be performed as a series of overlapping tests.

- Molded case circuit breakers should periodically be manually exercised and inspected to ensure ease of operation. On a rotating refueling outage basis, a sample of these breakers should be tested to determine that breaker drift is within that allowed by the design criteria. Breakers should be tested in accordance with an accepted quality control testing methodology.

- Fuses, when used as interrupting devices, do not require periodic testing because of their stability, lack of drift, and high reliability. Administrative controls should ensure that replacement fuses with ratings other than those selected for proper coordinating are not accidentally used.

5.5.4.2 Spurious Operation Circuits. Provide a means to isolate the equipment and components from the fire area prior to the fire (i.e., remove power, open circuit breakers).

Provide electrical isolation that prevents spurious operation. Potential isolation devices include breakers, fuses, amplifiers, control switches, current transformers, fiber optic couplers, relays, and transducers.

Provide a means to detect spurious operations and develop procedures to mitigate the maloperation of equipment (e.g., closure of the block valve if a PORV spuriously operates, opening of the breakers to remove spurious operation of safety injection).

5.5.4.3 Common Enclosures. Provide appropriate measures to prevent propagation of the fire.

Provide electrical protection (e.g., breakers, fuses, or similar devices).

The guidance in Regulatory Position 5.5.4 is based on GL 81-12 and IN 88-45.

5.6 Alternative, Dedicated, or Backup Shutdown Capability

5.6.1 General Guidelines

Alternative, dedicated, or backup shutdown capability and its associated circuits, independent of cables, systems, or components in the area, room, or zone under consideration, should be provided:

a. In areas where the fire protection features cannot ensure safe shutdown capability in the event of a fire in that area (i.e., where the protection of systems whose functions are required for hot shutdown does not satisfy the criteria of Regulatory Position 5.5) or

b. Where redundant success paths of systems required for hot shutdown located in the same fire area may be subject to damage from fire suppression activities or from the rupture or inadvertent operation of fire suppression systems.

Fire detection and a manually actuated fixed water suppression system or an automatically actuated gaseous suppression system should be installed in the area, room, or zone under consideration.

While independence is clearly achieved where alternative shutdown equipment is outside the fire area under consideration, alternative shutdown equipment in the same fire area but independent of the room or the zone under consideration may be acceptable. Where alternative, dedicated, or backup shutdown is provided for a room or zone, the capability should be physically and electrically independent of that room or zone. The vulnerability of the equipment and personnel required at the location of the alternative, dedicated, or backup shutdown capability to the environments produced at that location as a result of the fire or fire suppressants should be evaluated. These environments may be due to the hot layer, smoke, drifting suppressants, common ventilation systems, common drain systems, or flooding. In addition, other interactions between the locations may be possible in unique configurations. Therefore, the “room” concept should be justified by a detailed fire hazards analysis that demonstrates a single fire will not disable both normal shutdown equipment and the alternative shutdown capability.

The alternative, dedicated, or backup shutdown capability for specific fire areas may be unique for each such area, or it may be one unique combination of systems for all such areas. In either case, the alternative shutdown capability should be independent of the specific fire areas and should accommodate post-fire conditions where offsite power is available and where offsite power is not available for 72 hours. Procedures to implement the alternative or dedicated shutdown capability should be provided as described in Regulatory Position 5.7 of this guide.

The performance goals and criteria for alternative or dedicated shutdown are described in Regulatory Position 5.2 of this guide.

The guidance in Regulatory Position 5.6.1 is based on Appendix R to 10 CFR Part 50, CMEB 9.5-1, GL 81-12, GL 86-10, and IN 84-09.

5.6.2 Control Room Fires

The control room fire area contains the controls and instruments for redundant shutdown systems in close proximity (usually separation is a few inches). Remote shutdown capability and its associated circuits for the control room should be independent of the cables, systems, and components in the control room fire area.

The damage to systems in the control room for a fire that causes evacuation of the control room cannot be predicted. A bounding analysis should be made to assure that safe conditions can be maintained from outside the control room. This analysis is dependent on the specific design. The usual assumption are:

- The reactor is tripped in the control room.

- Offsite power is lost as well as automatic starting of the onsite ac generators and the automatic function of valves and pumps whose control circuits could be affected by a control room fire.

The analysis should demonstrate that capability exists to manually achieve safe shutdown conditions from outside the control room by restoring ac power to designated pumps, assuring that valve lineups are correct, and assuming that any malfunctions of valves that permit the loss of reactor coolant can be corrected before un-restorable conditions occur.

The only manual action in the control room prior to evacuation usually given credit for is reactor trip. For any additional control room actions deemed necessary prior to evacuation, a demonstration of the capability of performing such actions should be provided for staff review. Additionally, assurance would have to be provided that such actions could not be negated by subsequent spurious actuation signals resulting from the postulated fire.

Post-fire return to the control room should be governed by procedures and conditions as described in Regulatory Position 5.7.2 of this guide.

After returning to the control room, the operators can take any actions compatible with the condition of the control room. Controls in any area (cabinet where the fire occurred) may not be available. Smoke and fire suppressant damage in other areas (cabinets) should also be assessed and corrective action taken before controls in such cabinets are deemed functional. Controls in undamaged areas (cabinets) may be operated as required. Repairs inside the control room may be performed to reach cold shutdown.

The guidance in Regulatory Position 5.6.2 is based on GL 86-10.

5.7 Post-Fire Safe Shutdown Procedures

Procedures for effecting safe shutdown should reflect the results and conclusions of the safe shutdown analysis. Implementation of the procedures should not further degrade plant safety functions. Time-critical operations for effecting safe shutdown identified in the safe shutdown analysis and incorporated in post-fire procedures should be validated.

5.7.1 Safe Shutdown Procedures

The only requirement for post-fire safe shutdown operating procedures is for those areas where alternative or dedicated shutdown is required. For other areas of the plant, shutdown would normally be achieved using the normal operating procedures or plant emergency operating procedures.

5.7.2 Remote Shutdown Procedures

Procedures should be in effect that describe the tasks to implement remote shutdown capability where offsite power is available and where offsite power is not available for 72 hours. These procedures should also address necessary actions to compensate for spurious operations and high impedance faults if such actions are necessary to effect safe shutdown.

Procedures governing return to the control room should consider the following conditions:

- The fire has been extinguished and so verified by appropriate fire protection personnel;
- The control room has been deemed habitable by appropriate fire protection personnel and the shift supervisor;
- Damage has been assessed and, if necessary, corrective action has been taken to ensure that necessary safety, control, and information systems are functional (some operators may assist with these tasks), and the shift supervisor has authorized return of plant control to the control room;
- Turnover procedures that ensure an orderly transfer of control from the remote shutdown panel to the control room have been completed.

5.7.3 Repair Procedures

Procedures should be developed for performance of repairs necessary to achieve and maintain cold shutdown conditions. For alternative shutdown, procedures should be in effect to accomplish repairs necessary to achieve and maintain cold shutdown within 72 hours.

The performance of repair procedures should not adversely impact operating systems needed to maintain hot shutdown.

The guidance in Regulatory Position 5.7 is based on Appendix R to 10 CFR Part 50, CMEB 9.5-1, GL 81-12, GL 86-10, IN 84-09, and IP 64100.

6. FIRE PROTECTION FOR AREAS IMPORTANT TO SAFETY

Several areas within a nuclear power plant present unique hazards or design issues relative to fire protection and safe shutdown. Guidance applicable to specific plant areas is provided in this section.

6.1 Areas Related to Power Operation

6.1.1 Containment

Fire protection for the primary and secondary containment areas should be provided for the hazards identified in the fire hazard analysis. Under normal conditions, containment fire hazards may include lubricating oils, hydraulic fluids, cables, electrical penetrations, electrical cabinets, and charcoal filters. During refueling and maintenance operations, additional hazards may be introduced, including contamination control and decontamination materials and supplies, scaffolding, plastic sheathing, wood planking, chemicals, and hot work. The effects of postulated fires within the primary containment should be evaluated in the Fire Hazard Analysis to ensure that the integrity of the primary coolant system and containment is not jeopardized and the safe shutdown performance objectives described in Regulatory Position 5.1 of this guide are met, assuming no action is taken to fight the fire.

Guidance for reactor coolant pump oil collection is provided in Regulatory Position 7.1 of this guide.

6.1.1.1 Containment Electrical Separation. For secondary containment areas, cable fire hazards that could affect safety should be protected against as described in Regulatory Position 4.1.3.3.

Inside non-inerted containments, one of the fire protection means specified in Regulatory Position 5.5 or one of the following should be provided.

- Separation of cables and equipment and associated non-safety circuits of redundant success paths by a horizontal distance of more than 6.1 m (20 ft) with no intervening combustibles or fire hazards;

- Installation of fire detectors and an automatic fire suppression system in the fire area; or

- Separation of cables and equipment and associated non-safety circuits of redundant success paths by a noncombustible radiant energy shield having a minimum fire rating of one-half hour. The fire protection capability of the radiant energy shield may be demonstrated by testing or analysis.

6.1.1.2 Containment Fire Suppression. Fire suppression systems should be provided on the basis of a fire hazards analysis. During normal operations, containment is generally inaccessible and therefore fire protection should be provided by automatic fixed systems.

Automatic fire suppression capability need not be provided in primary containment atmospheres that are inerted during normal operations. However, inerted containments should have manual firefighting capability, including standpipes, hose stations, and portable extinguishers, to provide protection during refueling and maintenance operations.

Standpipe and hose stations should also be installed inside PWR containments and BWR containments that are not inerted. Standpipe and hose stations inside containment may be connected to a high-quality water supply of sufficient quantity and pressure other than the fire main loop if plant-specific features prevent extending the fire main supply inside containment. For BWR drywells, standpipe and hose stations should be placed outside the drywell with adequate lengths of hose, no longer than 30.5 m (100 ft), to reach any location inside the drywell with an effective hose stream.

The containment penetration of the standpipe system should meet the isolation requirements of GDC 56 of Appendix A to 10 CFR Part 50 and should be Seismic Category 1 and Quality Group B.

Operation of the fire protection systems should not compromise the integrity of the containment or other systems important to safety. 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.

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.

6.1.1.3 Containment Fire Detection. Fire detection systems should alarm and annunciate in the control room. In primary containment, fire detection systems should be provided for each fire hazard. For primary and secondary containment, 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 in the air recirculation system ahead of any filters.

The guidance in Regulatory Position 6.1.1 is based on Appendix R to 10 CFR Part 50, CMEB 9.5-1, and GL 86-10.

6.1.2 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 3 hours. Peripheral rooms in the control room complex should have automatic water suppression and should be separated from the control room

by noncombustible construction with a fire resistance rating of 1 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 gas extinguishing system is used for fire suppression, these dampers should be strong enough to support the pressure rise accompanying the agent discharge and seal tightly against infiltration of the agent into the control room. Carbon dioxide total flooding systems are not acceptable for these areas.

Breathing apparatus for control room operators should be readily available.

All cables that enter the control room should terminate in the control room. That is, no cabling should be routed through the control room from one area to another. Cables in under-floor and ceiling spaces should meet the separation criteria necessary for fire protection.

Equipment important to safety 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.

There should be no carpeting in the control room. Where carpeting has been installed (e.g., for sound abatement or other human factors), the carpeting should be tested to standards such as ASTM D2859, "Standard Test Method for Flammability of Finished Textile Floor Covering Materials," to establish the flammability characteristics of the material. These characteristics should be addressed in the fire hazards analysis.

6.1.2.1 Control Room Fire Suppression. Manual firefighting capability should be provided for both:

a. Fire originating within a cabinet, console, or connecting cables; and

b. 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 inside or 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.

Fully enclosed electrical raceways located in under-floor and ceiling spaces, if over 0.09 m^2 (1 sq ft) in cross-sectional area, should have automatic fire suppression inside. Area automatic fire suppression should be provided for under-floor and ceiling spaces if used for cable runs unless all cable is run in 10 cm (4-inch) or smaller steel conduit or the cables are in fully enclosed raceways internally protected by automatic fire suppression.

6.1.2.2 Control Room Fire Detection. 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.

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.

6.1.2.3 Control Room Ventilation. 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.

Air-handling functions should be ducted separately from cable runs in ceiling and floor spaces. If cables are routed in under-floor or ceiling spaces, these spaces should not be used as air plenums for ventilation of the control room.

The guidance in Regulatory Position 6.1.2 is based on APCSB 9.5-1 and CMEB 9.5-1.

6.1.3 Cable Spreading Room

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 3 hours. If this is not possible, an alternative, dedicated, or backup shutdown capability should be provided.

Cable spreading rooms should have:

a. At least two remote and separate entrances for access by fire brigade personnel;
b. An aisle separation between tray stacks at least 0.9 m (3 ft) wide and 2.4 m (8 ft) high;
c. Hose stations and portable extinguishers installed immediately outside the room; and
d. Area fire detection.

If division cables are not separated by 3-hour barriers, separation should meet the guidelines of Regulatory Guide 1.75 and the cables should have a suitable fire retardant coating.

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. Determination of the 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 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.

Alternative gas systems (Halon, clean agent, 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.

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.

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.

The guidance in Regulatory Position 6.1.3 is based on APCSB 9.5-1 and CMEB 9.5-1.

6.1.4 Plant Computer Rooms

Computer rooms for computers performing functions important to safety 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 3 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 6.1.2 for peripheral rooms. 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 plant areas important to safety by fire barriers with a minimum rating of 3 hours and should be protected as needed to prevent fire and smoke damage to equipment important to safety. Manual hose stations and portable extinguishers should be located in areas containing equipment important to safety. NFPA 75, "Standard for the Protection of Electronic Computer/Data Processing Equipment," provides additional guidance.

The guidance in Regulatory Position 6.1.4 is based on CMEB 9.5-1.

6.1.5 Switchgear Rooms

Switchgear rooms containing equipment important to safety should be separated from the remainder of the plant by barriers with a minimum fire rating of 3 hours. Redundant switchgear safety divisions should be separated from each other by barriers with a 3-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 fire hazard. These rooms should not be used for any other purpose. Automatic fire suppression should be provided consistent with other safety considerations. 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 (see Regulatory Position 4.1.5) should be provided to prevent water accumulation from damaging equipment important to safety. Remote manually actuated ventilation should be provided for venting smoke when manual fire suppression effort is needed (see Regulatory Position 4.1.4).

The guidance in Regulatory Position 6.1.5 is based on CMEB 9.5-1.

6.1.6 Remote Shutdown Panels

Panels providing remote shutdown capability should be separated from the control room complex by barriers having a minimum fire rating of 3 hours. Panels providing remote shutdown capability should be electrically isolated from the control room complex so that a fire in either area will not affect shutdown capability from the other area. The general area housing remote panels important to safety 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.

The guidance in Regulatory Position 6.1.6 is based on CMEB 9.5-1.

6.1.7 Station Battery Rooms

Battery rooms important to safety 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 3 hours inclusive of all penetrations and openings. DC 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%. Loss of ventilation should be alarmed in the control room. Standpipes, hose stations, and portable extinguishers should be readily available outside the room.

The guidance in Regulatory Position 6.1.7 is based on CMEB 9.5-1.

6.1.8 Diesel Generator Rooms

Diesel generators should be separated from each other and from other areas of the plant by fire barriers that have a fire resistance rating of at least 3 hours.

Automatic fire suppression should be installed to suppress or control 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 4164 L (1100 gallons) may be located in the diesel generator area under the following conditions:

a. The day tank is located in a separate enclosure with a fire resistance rating of at least 3 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

b. 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.

The guidance in Regulatory Position 6.1.8 is based on CMEB 9.5-1.

6.1.9 Pump Rooms

Pump houses and rooms housing redundant pump trains important to safety should be separated from each other and from other areas of the plant by fire barriers having at least 3-hour ratings. These rooms should be protected by automatic fire detection and suppression unless a fire hazards analysis can demonstrate that a fire will not endanger other 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.

Equipment pedestals, curbs, and floor drains should be provided to prevent water accumulation from damaging equipment important to safety (see Regulatory Position 4.1.5).

Provisions should be made for manual control of the ventilation system to facilitate smoke removal if required for manual firefighting operation (see Regulatory Position 4.1.4).

The guidance in Regulatory Position 6.1.9 is based on CMEB 9.5-1.

6.2 Other Areas

Other areas within the plant may contain hazards or equipment that warrant special consideration relative to fire protection, including areas containing significant quantities of radioactive materials, yard areas containing water supplies or systems important to safety, and the plant cooling tower.

6.2.1 New Fuel Areas

Portable hand extinguishers should be located near 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 maintained to preclude criticality for any water density that might occur during fire water application.

The guidance in Regulatory Position 6.2.1 is based on CMEB 9.5-1.

6.2.2 Spent Fuel Areas

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.

The guidance in Regulatory Position 6.6.2 is based on CMEB 9.5-1.

6.2.3 Radwaste Building/Storage Areas and Decontamination Areas

Radioactive waste buildings, storage areas, and decontamination areas should be separated from other areas of the plant by fire barriers having at least 3-hour ratings. Automatic sprinklers should be used in all areas where combustible materials are located. Alternatively, manual hose stations and portable extinguishers (hand-held and large wheeled units sized according to the hazards) are acceptable. Automatic fire detection should be provided to annunciate and alarm in the control room and alarm locally. Ventilation systems in these areas should be capable of being isolated to prevent the release of radioactive materials to other areas or the environment. Water from firefighting activities should drain to liquid radwaste collection systems.

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.

The guidance in Regulatory Position 6.2.3 is based on CMEB 9.5-1.

6.2.4 Dry Cask Spent Fuel Storage Areas

Fire protection of dry cask storage is addressed by the requirements of 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste." In addition to the requirements of 10 CFR Part 72, fire protection for independent spent fuel storage installations should ensure that fires involving such installations will not impact plant operations and plant areas important to safety.

6.2.5 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.

The guidance in Regulatory Position 6.2.5 is based on CMEB 9.5-1.

6.2.6 Cooling Towers

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

The guidance in Regulatory Position 6.2.6 is based on CMEB 9.5-1.

7. PROTECTION OF SPECIAL FIRE HAZARDS EXPOSING AREAS IMPORTANT TO SAFETY

7.1 Reactor Coolant Pump Oil Collection

The reactor coolant pump (RCP) should be equipped with an oil collection system if the containment is not inerted during normal operation. The oil collection system should be so designed, engineered, and installed that failure will not lead to fire during normal or design basis accident conditions and that there is reasonable assurance that the system will withstand the safe shutdown earthquake.

Such collection systems should be capable of collecting lube oil from all potential pressurized and unpressurized leakage sites in the RCP lube oil systems. Leakage should be collected and drained to a vented closed container that can hold the entire lube oil system inventory. A flame arrester is required in the vent if the flashpoint characteristics of the oil present the hazard of fire flashback. Leakage points to be protected should include, but are not limited to, lift pump and piping, overflow lines, lube oil cooler, oil fill and drain lines and plugs, flanged connections on oil lines, and lube oil reservoirs where such features exist on the RCPs. The drain line should be large enough to accommodate the largest potential oil leak.

One or more tanks need to be provided with sufficient capacity to collect the total lube oil inventory from all RCPs draining to the container.

Alternatives that may be acceptable are:

a. One or more tanks are provided with sufficient capacity to hold the total lube oil inventory of one RCP with margin if the tank is located such that any overflow from the tank will be drained to a safe location where the lube oil will not present an exposure fire hazard to or otherwise endanger equipment important to safety; or

b. Where the RCP lube oil system is shown, by analysis, to be capable of withstanding the safe shutdown earthquake (SSE) (eliminating the consideration of simultaneous lube oil system ruptures from a seismic event), protection is provided for random leaks at mechanical joints in the lube oil system (e.g., flanges, RTD connections, sightglasses). Alternative methods of protection may be deemed acceptable for such designs. In RCP lube oil collection systems of such designs, one or more tanks need to be provided with sufficient capacity to hold the total lube oil inventory of one RCP with margin. Because protection is required only against possible leakage resulting from random leaks from the one pump at a time, any overflow from the tanks need not be considered; or

c. For pumps with the lube oil contained entirely within the pump casing, an oil collection system may not be required provided it can be shown that there are no potentially significant leakage points.

The guidance in Regulatory Position 7.1 is based on Appendix R to 10 CFR Part 50, CMEB 9.5-1, GL 86-10, IN 84-09, and Vollmer Memo (1983a).

7.2 Turbine/Generator Building

The turbine building should be separated from adjacent structures containing equipment important to safety by a fire barrier with a rating of at least 3 hours. The fire barriers should be designed to maintain structural integrity even in the event of a complete collapse of the turbine structure. 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.

The guidance in Regulatory Position 7.2 is based on CMEB 9.5-1.

7.2.1 Oil Systems

Turbine buildings contain large sources of combustible liquids, including reservoirs and piping for lube oil, seal oil, and electro-hydraulic systems. These systems should be separated from systems important to safety by 3-hour rated barriers. Additional protection should be provided on the basis of the hazard, or where fire barriers are not provided. (See Regulatory Position 2.1.3.)

The guidance in Regulatory Position is based on ASB 9.5-1.

7.2.2 Hydrogen System

Turbine-generators may use hydrogen for cooling. Hydrogen storage and distribution systems should meet the guidelines provided in Regulatory Position 7.5 of this guide.

7.2.3 Smoke Control

Smoke control should be provided in the turbine building to mitigate potential heavy smoke conditions associated with combustible liquid and cable fires. Specific guidance is provided in Regulatory Position 4.1.4 of this guide.

7.3 Station Transformers

Transformers installed inside fire areas containing systems important to safety should be of the dry type or insulated and cooled with noncombustible liquid. Transformers filled with combustible fluid that are located indoors should be enclosed in a transformer vault. Additional guidance is provided in NFPA 70.

Outdoor oil-filled transformers should have oil spill confinement features or drainage away from the buildings. Such transformers should be located at least 15.2 m (50 ft) distant from the building, or building walls within 15.2 m (50 ft) of oil-filled transformers should be without openings and have a fire resistance rating of at least 3 hours.

The guidance in Regulatory Position 7.3 is based on CMEB 9.5-1.

7.4 Diesel Fuel Oil Storage Areas

Diesel fuel oil tanks with a capacity greater than 4164 L (1,100 gallons) should not be located inside buildings containing equipment important to safety. If above-ground tanks are used, they should be located at least 15.2 m (50 ft) from any building containing equipment important to safety, or if located within 15.2 m (50 ft), they should be housed in a separate building with construction having a minimum fire resistance rating of 3 hours. Potential oil spills should be confined or directed away from buildings containing equipment important to safety. Totally buried tanks are acceptable outside or under buildings (see NFPA 30 for additional guidance).

Above-ground oil storage, including those tanks located in a separate building, should be protected by an automatic fire suppression system.

The guidance in Regulatory Position 7.4 is based on CMEB 9.5-1.

7.5 Flammable Gas Storage and Distribution

Bulk gas storage (either compressed or cryogenic) should not be permitted inside structures housing equipment important to safety. Storage of flammable gas such as hydrogen should be located outdoors or in separate detached buildings so that a fire or explosion will not adversely affect any systems or equipment important to safety. NFPA 50A and 50B provide additional guidance.

Care should be taken to locate high-pressure gas storage containers with the long axis parallel to building walls. This will minimize the possibility of wall penetration in the event of a container failure. Acetylene-Oxygen gas cylinder storage locations should not be in areas that contain or expose equipment important to safety or the fire protection systems that serve those equipment areas. A permit system should be required for use of Acetylene-Oxygen gas storage cylinders in areas of the plant important to safety. NFPA 55, "Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders," provides additional guidance.

Risks to equipment important to safety from hydrogen supply systems can be minimized by designing hydrogen lines in plant areas important to safety to Seismic Class I requirements, sleeving the piping such that the pipe is directly vented to the outside, or through the use of restricting orifices or excess flow valves to limit the maximum flow rate from the storage facility to the areas of concern so that in case of a line break, the hydrogen concentration in the affected areas will not exceed 2%. This approach includes pre-operational testing and subsequent retesting of excess flow valves and measures to prevent buildup of unacceptable amounts of trapped hydrogen and inadvertent operation with the safety features bypassed. A somewhat less cost-effective alternative involves use of a normally isolated supply with intermittent manual makeup. Additional guidelines and criteria for the design, installation, and operation of flammable cryogenic and compressed gas systems are provided in EPRI NP-5283-SR-A.

The guidance in Regulatory Position 7.5 is based on CMEB 9.5-1 and GL 93-06.

D. IMPLEMENTATION

The purpose of this section is to provide information to licensees regarding the NRC staff's plans for using this regulatory guide. No backfitting is intended or approved in connection with the issuance of this guide.

Except in those cases in which a licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the methods described in this guide will be used in the evaluation of licensee compliance with the requirements of 10 CFR 50.48. This guide will also be used to evaluate submittals from operating reactor licensees who propose changes to their fire protection programs that are initiated by the licensee if there is a clear nexus between the proposed change and this guidance.

GLOSSARY

Alternative Shutdown — The capability to safely shut down the reactor in the event of a fire using existing systems that have been rerouted, relocated, or modified.

Approved — Tested and accepted for a specific purpose or application by a recognized testing laboratory.

Associated Circuits — Circuits that do not meet the separation requirements for safe shutdown systems and components and are associated with safe shutdown systems and components by common power supply, common enclosure, or the potential to cause spurious operations that could prevent or adversely affect the capability to safely shut down the reactor as a result of fire-induced failures (hot shorts, open circuits, and short to ground).

Automatic — Self-acting, operating by its own mechanism when actuated by some monitored parameter such as a change in current, pressure, temperature, or mechanical configuration.

Combustible Material — Any material that will burn or sustain the combustion process when ignited or otherwise exposed to fire conditions.

Common Enclosure — An enclosure (e.g., cable tray, conduit, junction box) that contains circuits required for the operation of safe shutdown components and circuits for non-safe shutdown components.

Common Power Supply — A power supply that feeds safe shutdown circuits and non-safe shutdown circuits.

Control Room Complex — The zone served by the control room emergency ventilation system.

Dedicated Shutdown — The ability to shut down the reactor and maintain shutdown conditions using structures, systems, or components dedicated to the purpose of accomplishing post-fire safe shutdown functions.

Emergency Control Station — Location outside the main control room where actions are taken by operations personnel to manipulate plant systems and controls to achieve safe shutdown of the reactor.

Exposure Fire — A fire in a given area that involves either in situ or transient combustibles and is external to any structures, systems, and components located in or adjacent to that same area. The effects of such fire (e.g., smoke, heat, or ignition) can adversely affect those structures, systems, and components important to safety. Thus, a fire involving one success path of safe shutdown equipment may constitute an exposure fire for the redundant success path located in the same area, and a fire involving combustibles other than either redundant success path may constitute an exposure fire to both redundant trains located in the same area.

Fire Area — The portion of a building or plant that is separated from other areas by rated fire barriers adequate for the fire hazard.

Fire Barrier — 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, that are used to prevent the spread of fire.

Fire Brigade — A team of on-site plant personnel that have been qualified and equipped to perform manual fire suppression activities.

Fire Hazard — The existence of conditions that involve the necessary elements to initiate and support combustion, including in situ or transient combustible materials, ignition sources (e.g., heat, sparks, open flames), and an oxygen environment.

Fire Hazard Analysis — An analysis used to evaluate the capability of a nuclear power plant to perform safe shutdown functions and minimize radioactive releases to the environment in the event of a fire. The analysis includes the following features:

- Identification of fixed and transient fire hazards.
- Identification and evaluation of fire prevention and protection measures relative to the identified hazards.
- Evaluation of the impact of fire in any plant area on the ability to safely shut down the reactor and maintain shutdown conditions, as well as to minimize and control the release of radioactive material.

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 Resistance — The ability of an element of building construction, component, or structure to fulfill, for a stated period of time, the required load-bearing functions, integrity, thermal insulation, or other expected duty specified in a standard fire-resistance test.

Fire Resistance Rating — The time that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251.

Fire Retardant Material — Means material that has been coated or treated with chemicals, paints, or other materials that are designed to reduce the combustibility of the treated material.

Fire Risk — Refers to the combination of the probability of a given fire event occurring and the estimated consequences of the event should it occur.

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 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 Watch — Individuals responsible for providing additional (e.g., during hot work) or compensatory (e.g., for system impairments) coverage of plant activities or areas for the purposes of detecting fires or for identifying activities and conditions that present a potential fire hazard. The individuals should be trained in identifying conditions or activities that present potential fire hazards, as well as the use of fire extinguishers and the proper fire notification procedures.

Fire Zones — Subdivisions of fire areas.

Free of Fire Damage — The structure, system, or component under consideration is capable of performing its intended function during and after the postulated fire, as needed, without repair.

Hazardous Material — A substance that, upon release, has the potential of causing harm to people, property, or the environment.

High Impedance Fault — A circuit fault condition resulting in a short to ground, or conductor to conductor hot short, where residual resistance in the faulted connection maintains the fault current level below the component's circuit breaker long-term setpoint.

Hot Short — Individual conductors of the same or different cables come in contact with each other and may result in an impressed voltage or current on the circuit being analyzed.

Hot Work — Activities that involve the use of heat, sparks, or open flame such as cutting, welding, and grinding.

Impairment — The degradation of a fire protection system or feature that adversely affects the ability of the system or feature to perform its intended function.

Important to Safety — Nuclear power plant structures, systems, and components "important to safety" are those required to provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public.

Interrupting Device — A breaker, fuse, or similar device installed in an electrical circuit to isolate the circuit (or a portion of the circuit) from the remainder of the system in the event of an overcurrent or fault downstream of the interrupting device.

In situ Combustibles — Combustible materials that constitute part of the construction, fabrication, or installation of plant structures, systems, and components and as such are fixed in place.

Isolation Device — A device in a circuit that prevents malfunctions in one section of a circuit from causing unacceptable influences in other sections of the circuit or other circuits.

Listed — Equipment or materials included on a list published by a recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials, and whose listing states that certain specific equipment or materials meet nationally recognized standards and have been tested and found suitable for use in a specified manner.

Noncombustible Material — (a) Material that, in the form in which it is used and under conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat or (b) material having a structural base of noncombustible material, with a surfacing not over 1/8 inch thick that has a flame spread rating not higher than 50 when measured in accordance with ASTM E-84, "Standard Test Method for Surface Burning Characteristics of Building Materials."

Open Circuit — A failure condition that results when a circuit (either a cable or individual conductor within a cable) loses electrical continuity.

Pre-Fire Plans — Documentation that describes the facility layout, access, contents, construction, hazards, hazardous materials, types and locations of fire protection systems, and other information important to the formulation and planning of emergency fire response.

Raceway — An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted by code. Raceways include, but are not limited to, rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquid-tight flexible conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

Raceway Fire Barrier — Non-load-bearing partition type envelope system installed around electrical components and cabling that are rated by test laboratories in hours of fire resistance and are used to maintain safe shutdown functions free of fire damage.

Radiant Energy (Heat) Shield — A noncombustible or fire resistive barrier installed to provide separation protection of redundant cables, equipment, and associated non-safety circuits within containment.

Remote Shutdown — The capability, including necessary instrumentation and controls, to safely shut down the reactor and maintain shutdown conditions from outside the main control room. (See GDC 19.)

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

Safe Shutdown — For fire events, those plant conditions specified in the plant Technical Specifications as Hot Standby, Hot Shutdown, or Cold Shutdown.

Safe Shutdown Analysis — A process or method of identifying and evaluating the capability of structures, systems, and components necessary to accomplish and maintain safe shutdown conditions in the event of a fire.

Safe Shutdown System/Safe Shutdown Equipment — Systems and equipment that perform functions needed to achieve and maintain safe shutdown (regardless of whether or not the system or equipment is part of the success path for safe shutdown).

Safety-Related Systems and Components — Systems and components required to mitigate the consequences of postulated design basis accidents.

Secondary Containment — The combination of physical boundary and ventilation systems designed to limit the release of radioactive material.

Short Circuit — A failure condition that results when a circuit (either a cable or individual conductor within a cable) comes into electrical contact with another circuit.

Short-to-Ground — A failure condition that results when a circuit (either a cable or individual conductor within a cable) comes into electrical contact with a grounded conducting device such as a cable tray, conduit, grounded equipment, or other grounded component.

Spurious Operation — The undesired operation of equipment resulting from a fire that could affect the capability to achieve and maintain safe shutdown.

Standards (Code) of Record — The specific editions of the standards that constitute the licensing or design basis for the plant.

Success Path — The minimum set of structures, systems, and components necessary to achieve and maintain safe shutdown in the event of a fire.

Temporary Structures — Buildings, tents, shelters, platforms, trailers, or other structures that are erected for the purpose of supporting plant operations and maintenance, but are not permanent site facilities.

Turnout Gear — Personnel protective clothing for fire fighting such as coats, pants, boots, helmets, gloves, and self-contained breathing apparatus (SCBA).

Transient Combustibles — Combustible materials that are not fixed in place or an integral part of an operating system or component.

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APPENDIX A: EQUIVALENCY

This appendix provides information and previously accepted examples from Generic Letter 86-10[(1)] with regard to the use of equivalency in evaluating fire protection and safe shutdown features.

A-1 Process Monitoring Instrumentation

Section III.L.2.d of Appendix R to 10 CFR Part 50 states that "The process monitoring function shall be capable of providing direct readings of the process variables necessary to perform and control" the reactivity control function. Regulatory Positions 5.3 and 5.4 of this guide provide a list of instrumentation acceptable to and preferred by the staff to demonstrate compliance with this provision. While this guidance provides an acceptable method for compliance with the regulation, it does not exclude other alternative methods of compliance. Alternative instrumentation to comply with the regulation (e.g., boron concentration indication) should be justified based on a technical evaluation.

A-2 Fire Area Boundaries

The term "fire area" as used in Appendix R means an area sufficiently bounded to withstand the hazards associated with the area and, as necessary, to protect important equipment within the area from a fire outside the area. In order to meet the regulation, fire area boundaries need not be completely sealed floor-to-ceiling, wall-to-wall boundaries. However, all unsealed openings should be identified and considered in evaluating the effectiveness of the overall barrier. Where fire area boundaries are not wall-to-wall, floor-to-ceiling boundaries with all penetrations sealed to the fire rating required of the boundaries, licensees should perform an evaluation to assess the adequacy of fire boundaries in their plants to determine whether the boundaries will withstand the hazards associated with the area. This analysis should be performed by at least a fire protection engineer and, if required, a systems engineer. However, if certain cable penetrations were identified as open SER items at the time Appendix R became effective, Section III.M of the rule applies (see 10 CFR 50.48(b)), and any variation from the requirements of Section III.M requires an exemption. In any event, these analyses should be retained by the licensees for subsequent NRC audits.

A-3 Automatic Detection and Suppression

Sections III.G.2.b and III.G.2.c of Appendix R state that "In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area." Other provisions of Appendix R (e.g., Section III.G.2.e) also use the phrase "fire detectors and an automatic fire suppression system in the fire area."

In order to comply with these provisions, suppression and detection sufficient to protect against the hazards of the area should be installed. In this regard, detection and suppression providing less than full area coverage may be adequate to comply with the regulation. Where full area suppression and detection is not installed, licensees should perform an evaluation to assess the adequacy of partial suppression and detection to protect against the hazards in the area. The

[1]Generic Letter 86-10, "Implementation of Fire Protection Requirements," USNRC, April 24, 1986.

evaluation should be performed by a fire protection engineer and, if required, a systems engineer. The evaluations should be retained for subsequent NRC audits. If a licensee is providing no suppression or detection, an exemption or license amendment should be requested.

REGULATORY ANALYSIS

A regulatory analysis was published with the draft of this guide when it was issued for public comment (Task DG-1097, June 2000). No changes were necessary, so a separate regulatory analysis for Regulatory Guide 1.189 has not been prepared. A copy of the regulatory analysis is available for inspection or copying for a fee in the NRC's Public Document Room at 11555 Rockville Pike, Rockville, Maryland.

BACKFIT ANALYSIS

This regulatory guide does not require a backfit analysis as described in 10 CFR 50.109(c) because it does not impose a new or amended provision in the NRC's rules or a regulatory staff position interpreting the Commission rules that is either new or different from a previous applicable staff position. In addition, this regulatory guide does not require the modification or addition to systems, structures, components, or design of a facility or the procedures or organization required to design, construct, or operate a facility. Rather, a licensee can select a preferred method for achieving compliance with a license or the rules or the orders of the Commission as described in 10 CFR 50.109(a)(7). This regulatory guide provides an opportunity to use the standards described herein if that is a licensee's preferred method.