UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of)
)
CAROLINA POWER AND LIGHT COMPANY AND)
NORTH CAROLINA EASTERN MUNICIPAL) Docket Nos. 50-400 OL
POWER AGENCY) 50-401 OL
)
(Shearon Harris Nuclear Power Plant,)
Units 1 and 2))

NRC STAFF TESTIMONY OF RANDALL EBERLY AND ROBERT L. FERGUSON CONCERNING EDDLEMAN CONTENTION 116

Q1. Mr. Eberly, please state your name, affiliation and position.

A1. My name is Randall Eberly. I am a fire protection Engineer in the Chemical Engineering Branch, Division of Engineering, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission. I am the Staff fire protection reviewer for the Shearon Harris Nuclear plant.

Q2. Please summarize your professional qualifications.

A2. In 1975 I received a Bachelor of Science Degree in Fire Protection Engineering from The University of Maryland.

I am a registered Professional Engineer in the States of Maryland and Delaware.

I serve on the National Fire Protection Association Technical Committees on Halon Fire Extinguishing Systems and Portable Fire Extinguishers.

During my attendance at the University of Maryland, I was involved in a cooperative program with the United States Coast Guard. I was employed, part-time as a fire protection engineering trainee with the Hull Arrangements Branch, Merchant Marine Technical Division, Office of Merchant Marine Safety, U.S. Coast Guard Headquarters. At that time my duties included the review and approval of fire protection systems and materials for U.S. and foreign flag merchant vessels.

I joined the civilian staff of the U.S. Coast Guard, full-time, in 1975. My duties were expanded to include marine fire protection research, casualty investigation, and I also served as an advisor to the U.S. Department of State for the purposes of negotiating international maritime fire protection and safety regulations. During my employment with the Coast Guard, I was responsible for the review and approval of the fire protection aspects of the Floating Nuclear Power Plants (FNP). I received a High Quality Increase for this work.

In 1982, I joined the U.S. NRC in my present position. My duties include the review and approval of fire protection programs of Nuclear Power plants. I also serve as a fire protection technical expert on Regional fire protection team inspections. Since I have been with the NRC, I have reviewed the fire protection programs of approximately 25 nuclear power plants. I was awarded a Certificate of Appreciation for my involvement in the Appendix R fire protection backfit program.

Q3. Mr. Ferguson, please state your name, affiliation and position.

A3. My name is Robert L. Ferguson. I am the Section Leader of the Fire protection Section, Chemical Engineering Branch, Division of Engineering, Office of Nuclear Reactor Regulation, United States Nuclear Regulatory Commission.

Q4. Please summarize your professional qualifications.

A4. I am a Section Leader in the Division of Engineering. I am responsible for supervising the Staff's review of the safety considerations associated with fire protection programs at nuclear power generating stations.

I received a Bachelor of Science degree in Electrical Engineering from the Illinois Institute of Technology in 1950.

From 1950 to 1956 I was employed at Argonne National Laboratory, Lemont, Illinois. As Associate Engineer, I was responsible for the development of instrumentation, controls, and data handling systems for nuclear reactors, special process loops, and experiments in physics, chemistry, biology and nondestructive testing.

From 1956 to 1959 I was employed at ACF Industries, Washington, D.C. As Manager of the Instrumentation, Control, and Electrical Section, I was responsible for the design of instrumentation, control, and electrical systems for several reactor facilities.

From 1959 to 1960 I was employed at Curtiss-Wright Corporation, Quehanna, Pennsylvania. As Manager of the Reactor Engineering Division, I was responsible for the design of nuclear reactor facilities and the design of components for nuclear reactors.

From 1960 to 1965 I was employed at Combustion Engineering, Inc. As Assistant Project Manager and later, as Project Manager for the High Flux Beam Reactor (HFBR), I was responsible for coordinating the design of the reactor, its shielding and its experimental facilities. As Engineering Supervisor following the completion of the HFBR, I was responsible for directing design studies related to pressurized water reactors, organic cooled D_2O moderated reactors, and liquid metal fast breeder reactors.

In December 1965, I joined the regulatory staff of the U.S. Atomic Energy Commission which subsequently became the Nuclear Regulatory Commission. Prior to my present assignment, which was made in 1977, I was responsible for the development of reactor standards, codes, and criteria relating to reactor safety and for advising other AEC divisions in related reactor safety matters from 1965 to 1971 and as a Senior Project Manager from 1971 to 1977, I was responsible for managing the Staff's review of the safety considerations associated with the design of nuclear powered generating stations.

In 1977, I was assigned the responsibility for developing, staffing and directing the Staff's evaluation of the fire protection programs at all operating plants. I participated in the subsequent development of all Staff fire protection requirements, the fire protection research program, and design studies of certain fire protection issues. Prior to issuance of Appendix A to BTP-APCSB 9.5-1, I participated in several site visits to determine the potential problems that may be encountered in applying the guidelines of BTP-APCSB 9.5-1 to operating plants and developing suitable alternative guidelines. I have participated in the evaluation of research results and plant incidents for indications of weaknesses in our present guidelines.

From 1968 to 1975 I participated in the American Nuclear Society's program to prepare standards pertinent to reactor safety. I was a member of two subcommittees of the ANS Standards Committee; i.e., ANS-20, Systems Engineering, and ANS-4, Reactor Dynamics and Control. From 1965 to 1970 I participated in the Institute of Electrical and Electronic Engineers' program to prepare standards pertinent to reactor safety. I was a member of the Joint Committee for Nuclear Power Standards and two of its subcommittees; i.e., S/C 4, Auxiliary Electrical Power, and S/C 2, Equipment Qualification.

Q5. What is the purpose of your testimony?

A5. The purpose of our testimony is to address Eddleman Contention 116 which states:

> The fire hazard analysis of section 9.5A (Appendix) in the FSAR does not address the availability of control and power to the safety equipment. In establishing fire

resistance ratings of fire barriers with respect to fires in cable trays, Applicants have not established that qualification tests represent actual plant conditions or comparable conditions. Another vague statement is that fire barriers are used "where practical" without defining practical or stating the criteria to decide where a fire barrier is or is not practical (and what type of fire barrier should be used). FSAR 9.5.1.1.1. The "analysis" of Appendix 9.5A does not demonstrate, as 9.5.1.1.1 claims it will, the adequacy of other fire protection measures in all cases. Rather, it estimates the BTU of combustible material, smoke generation and removal rate from the area, gives usually a qualitative description of some measures to mitigate or reduce fire effects, and assumes that the fire will be promptly detected (usually, no analysis of location of detection instruments, etc.) and the fire brigade will respond rapidly and put out the fire, or the automatic equipment will work. These assertions are made despite the time it takes to get people into the containment and to the fire (not well analyzed). Further, the "analysis" of what happens if the fire spreads is generally a rationalization that it can't spread much, not an analysis. See, e.g. "Analysis of Effects of postulated fires." The effect of a fire in a fire area or a fire zone with a combustible loading greater than 240,000 BTU/sq. ft. doesn't get dealt with in realistic terms. The plant firefighting capability for simultaneous fires is inadequate, or at least unanalyzed.

Q6. Mr. Eberly, have you reviewed the fire protection program for the Shearon Harris facility and, if so, where is that review documented?

A6. Yes. I have reviewed the Shearon Harris fire protection program which is contained in FSAR § 9.5.1, § 9.5A and "Safe Shutdown Analysis in Case of Fire" dated June 20, 1983. The Staff's review of that program is contained in § 9.5.1 of the Staff's Safety Evaluation Report (SER) dated November, 1983. In addition, there will be supplements to the SER dealing with open items identified in that section.

Q7. What is the purpose of the fire protection program.

A7. The purpose of the fire protection program is to ensure the capability to shut down the reactor and maintain it in a safe shutdown condition and to minimize radioactive releases to the environment in the event of a fire. It implements the philosophy of defense-in-depth protection against the hazards of fire and its associated effects on safety-related equipment.

Q8. What guidelines have been used to review the Applicants' fire protection program?

A8. The Applicants' fire protection program has been reviewed against the guidelines of § 9.5.1 of the Standard Review Plan (SRP) NUREG-0800, Rev. 3, July 1981.

Q9. Why is the fire protection program reviewed against these guidelines?

A9. General Design Criterion 3, "Fire Protection," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 C.F.R. Part 50, "Licensing of Production and Utilization Facilities," requires that structures, systems, and components important to safety be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Noncombustible and heat-resistant materials are required to be used wherever practical throughout the unit, particularly in locations such as the containment and control room. General Design Criterion 3 also requires that fire detection and suppression systems of appropriate capacity and capability be provided and designed to minimize the adverse effect of fires on structures, systems, and components important to safety and that fire fighting 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. If alternative designs or methods are used, they must provide equivalent fire protection. Suitable bases and justification should be provided for alternative approaches to establish acceptable implementation of General Design Criterion 3.

SRP § 9.5.1 presents guidelines acceptable to the NRC Staff for implementing this criterion in the development of a fire protection program for nuclear power plants. The guidelines include the technical requirements listed in a number of documents, including Appendix R to 10 C.F.R. Part 50 § 50.48.

To show conformance with GDC 3, a fire hazards analysis is performed by the Applicants which verifies that the NRC fire protection program guidelines have been met or that deviations from the guidelines are justified. The analysis lists applicable elements of the program, with explanatory statements as needed to identify location, type of system, and design criteria. The analysis identifies and justifies any deviations from the guidelines. Justification for deviations from the guidelines which show that an equivalent level of protection will be achieved are usually acceptable to the Staff. Deletion of a protective feature without compensating alternative protection measures will not be accepted by the NRC Staff if it is not clearly demonstrated that the protective measure is not needed because of the design and arrangement of the particular plant.

Q10. Have the Applicants performed a fire hazards analysis (FHA) to demonstrate that the plant will maintain the ability to perform safe shutdown functions and minimize radioactive releases to the environment in the event of a fire?

A10. Yes, it is provided in FSAR §§ 9.5 and 9.5A and "Safe Shutdown Analysis in Case of Fire," dated June 20, 1983.

Q11. Mr. Eberly, does the Applicants' FHA adequately describe and evaluate the fire hazards associated with each plant fire area?

A11. I have reviewed the Applicants' FHA to ascertain whether the information provided is sufficient to perform an independent evaluation of the fire hazards in each plant fire area, and to determine if adequate fire protection features are provided to mitigate the consequences of fire in accordance with our guidelines. It is my opinion that the information provided is adequate to perform this assessment.

Q12. What assurance does the NRC Staff need that fire barriers will be capable of protecting cables against fire damage?

A12. Because it is not feasible to test each and every cable tray configuration, the Staff relies on laboratory scale fire resistance tests of fire barrier material in representative configurations of cables and conduits.

Q13. Please describe the fire resistance tests for fire barriers used to protect cables.

A13. The Staff currently accepts fire barriers that have been successfully tested to ASTM Test Method E-119. "Fire Tests of Building Construction and Materials." This test method is a nationally recognized test method developed over 60 years ago. This test method is primarily intended for qualification testing of wall and floor assemblies. This test method is referenced by all national building codes as well as the National Fire Protection Association Standard for building construction.

The tests are conducted at independent, nationally recognized testing laboratories to insure objectivity. The test assemblies which are typically 180 ft.^{2} or larger are mounted in a test furnace and subjected to a standard test fire of carefully controlled extent and severity by calibrating the furnace to reproduce a specific time versus temperature curve. This fire is considered representative of an actual building fire which reaches a temperature of 1700°F in one hour and 1925°F in three hours.

Typically, several cable tray and conduit assemblies of varying configurations are tested. If, after the required exposure time, the protected cables remain free of fire damage, the fire barrier is considered acceptable.

Q14. Is it the Staff's position that these tests represent actual plant conditions or comparable conditions with respect to fires in cable trays?

A14. The Staff considers that these tests provide conservative conditions which envelope actual plant configurations.

Q15. Will the fire barriers to be installed at the Harris plant be tested in accordance with the Staff's recommended qualification test?

A15. Yes. The Applicants have committed to provide fire barriers that have successfully passed the ASTM E-119 test. However, a specific brand of fire barrier material has not yet been selected by the Applicants.

Q16. Will the Staff require the Applicants to submit test reports on the fire barriers chosen?

A16. If a product is selected that has been previously reviewed by the Staff and found acceptable, no further documentation is usually required. If, however a new product is proposed, then we would require the test report to be submitted to verify that acceptable, representative configurations have been tested using our acceptance criteria.

Q17. Do you feel that the Applicants' submittal is vague due to the statement that barriers are used "where practical" without defining practical?

A17. No. This statement is only a general description in FSAR § 9.5.1.1.1. The specific fire barrier locations and qualifications are contained in Appendix 9.5A and the Applicants' Safe Shutdown Analysis.

Q18. What criteria did the Applicants use to determine the location of fire barriers?

A18. The Applicants used the guidance of SRP 9.5-1 §§ C.5 and C.7 to determine where fire barriers should be located.

Q19. Does the Staff accept other alternatives to locating fire barriers in accordance with SRP § 9.5.1 §§ C.5 and C.7 if it is not feasible to erect such barriers?

A19. Yes. For example, in lieu of providing a fire barrier between redundant safe shutdown components in the control room, alternative safe shutdown capability independent of the area is provided. For other areas, a deviation could be requested for a combination of other features, e.g. partial height walls and automatic suppression systems if they provide an equivalent level of protection for the specific configuration.

Q20. How does the information provided in the Applicants' FHA demonstrate the adequacy of fire protection measures utilized?

A20. The Applicants' fire hazards analysis considers the potential in-situ and transient fire hazards in a fire area by calculating the available heat of combustion in BTUs of the available combustibles. This approximates the potential fire severity within each fire area. The consequences of a fire exposure of that potential magnitude are then evaluated in terms of damage to equipment installed in the fire area and the adequacy of the fire area boundaries. If redundant equipment that is required for safe shutdown located in the fire area could sustain damage, then appropriate fire protection measures are provided within the fire area.

Q21. What do these fire protection features for safe shutdown capability consist of?

A21. Our guidelines specify that in fire areas outside of the containment one train of cables and equipment necessary to achieve and maintain safe shutdown should be maintained free of fire damage by one of the following means:

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

b. Separation of cables and equipment and associated non-safety circuits of redundant trains by a horizontal distance of more than 20 feet with no intervening combustibles or fire hazards. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area; or

c. Enclosure of cables and equipment and associated non-safety circuits of one redundant train in a fire barrier having a 1-hour rating. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area.

If these conditions are not met, alternative shutdown capability independent of the fire area of concern should be provided.

These alternative requirements are not deemed to be equivalent for all configurations. However, they provide equivalent protection for those configurations in which they are accepted.

Inside non-inerted containments one of the above described fire protection means should be provided. If not, cables and equipment and associated non-safety circuits of redundant trains should be separated by a noncombustible radiant energy shield having a minimum fire rating of one-half hour.

Because it is not possible to predict the specific conditions under which fires may occur and propagate, the guidelines specify the design basis protective features rather than the design basis fires. Plant specific features may require protection different than the measures specified. In such a case, the licensee must demonstrate, by means of a detailed fire hazards analysis, that existing protection or existing protection in conjunction with proposed modifications will provide a level of safety equivalent to the guidelines of § C.5.b of BTP CMEB 9.5.1.

Our general criteria for accepting alternative fire protection configurations are the following:

The alternative assures that one train of equipment necessary to achieve hot shutdown from either the control room or emergency control station is free of fire damage.

The alternative assures that fire damage to at least one train of equipment necessary to achieve cold shutdown is limited such that it can be repaired within a reasonable time (minor repairs with components stored on-site).

The alternatives would not be detrimental to overall facility safety.

Q22 Describe the fire protection features for safe-shutdown to be employed at Harris.

A22. The Applicants' Safe Shutdown Analysis is contained in the FSAR § 9.5.1 and the "Safe Shutdown Analysis in case of fire" dated June 20, 1983. The Applicants' letters dated February 24, 1984 and June 12, 1984, provide additional information and clarification of the Safe Shutdown Analysis. The Applicants' report identifies 23 fire areas that comply with § C.5.b of BTP CMEB 9.5.1. Nine fire areas are identified where deviations from our guidelines have been requested.

We have reviewed the fire protection for safe shutdown to verify that one train of cables and equipment needed for safe shutdown will be maintained free of fire damage. Except for the deviations, all plant areas containing cables and equipment needed for safe shutdown are provided with fire protection measures consistent with § C.5.b of our guidelines.

In those areas where the fire protection measures for safe shutdown capability deviate from our guidelines, we have reviewed the Applicants' fire protection measures to determine if a level of safety equivalent to the technical requirements of § C.5.b of our guidelines has been provided; and based on our evaluation, we have concluded that an equivalent level of protection has been provided.

Q23. How are the fire protection features evaluated to determine their adequacy?

A23. These features are evaluated for compliance with our guidelines in § 9.5.1 of the SRP which recommends certain fire protection standards and codes that have been developed and accepted as national consensus standards. The code committees consist of prominent fire protection experts from varying backgrounds. Fire barriers are tested by nationally recognized testing laboratories to a standard fire test, ASTM E-119. Sprinkler systems and detection systems are designed to conform with National Fire Protection Association Codes. (NFPA) The rules for the location and spacing of sprinkler nozzles and fire detectors are specified in the NFPA codes. The Applicants' have committed to design suppression and detection systems in conformance with this guidance.

Q24. Do the fire protection guidelines in § 9.5.1 of the SRP rely solely on the response of the fire brigade or the operation of automatic extinguishing systems to protect equipment from any potential fires?

A24. No. Fire protection should be considered as a "program." Nuclear power plants use the concept of defense-in-depth to achieve the required high degree of safety by using echelons of safety systems. With respect to the fire protection program, the defense-in-depth principle is aimed at achieving an adequate balance in:

a. Preventing fires from starting;

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

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

No one of these echelons can be perfect or complete by itself. Each echelon should meet certain minimum requirements; however, strengthening any one can compensate in some measure for weaknesses, known or unknown, in the others.

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

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

Q25. Does this defense-in-depth concept take into account the time it takes for the response of the fire brigade?

A25. Yes. The Staff assumes that at least 30 minutes is required for the fire brigade to take action.

Q26. How have Applicants demonstrated that they comply with Staff guidance concerning defense-in-depth?

A26. The Applicants have submitted a Fire Hazards Analysis (FSAR § 9.5A) and a comparison (FSAR § 9.5) against the guidelines in SRP § 9.5.1. We have reviewed these submittals for conformance with our guidelines, however, our review is not yet complete. One element of our review requires us to make a site visit to field verify the Applicants' fire protection program. This visit can only be made at a very late stage of construction when the majority of the fire protection systems have been installed. After we have made our site visit and completed our technical review, we will be able to confirm that adequate defense-in-depth has been provided.

Q27. Should the FHA consider simultaneous fire events in different locations within the plant?

A27. No. Our guidelines in § 9.5.1 of the SRP, page 18 state that "On multiple-reactor sites, unrelated fires in two or more units need not be postulated to occur simultaneously." The Staff also uses the same guidelines to apply to single reactor sites.

Q28. Have Applicants conducted an analysis of the ability of a given type of fire to spread?

A28. To my knowledge, a specific analysis for this purpose has not been conducted, however, the prevention of fire spread is an inherent result of compliance with our guidelines. If the Applicants provide fire barriers, and fire detecting and extinguishing systems in conformance with SRP § 9.5.1 with approved deviations, the Staff accepts that an adequate level of protection has been provided against fire spread.

Q29. Are there any plant areas with a combustible loading in excess of 240,000 BTU's/ft.^{2}? Have they been properly addressed in the FHA?

A29. Yes. The areas identified as having a combustible loading of this magnitude are fire areas 1-D-DTA and 1-D-DTB, the Diesel Generator fuel oil day tank enclosures, and the buried fuel oil storage tanks in the yard area.

The FHA properly evaluates the fire hazard in these areas. The fuel oil day tanks are provided with three-hour boundary walls, floors, and ceiling, and automatic suppression and detection in accordance with our guidelines.

In the event of a fire in this area, heat detectors are provided which will automatically alarm and initiate the sprinkler system. A manual release for the sprinkler system is also provided. If the sprinkler system does not function, the fire brigade response will serve as a backup.

The buried fuel oil tanks require no specific fire protection features due to their isolated location, and distance from safety related equipment.

Q30. What are the Staff's conclusions as to the adequacy of the over-all fire protection program.

A30. Based upon Applicants written submittals the Staff has determined that an adequate fire protection program will be provided as evidenced by conformance with SRP § 9.5.1, with approved deviations, subject to the following open items:

(1) alternative safe shut down capability systems

(2) qualification of fire doors

(3) Staff site walk down

NUREG-0800
(Formerly NUREG-75/087)

EXHIBIT 7 RELATED CORRESPONDENCE

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

9.5.1 FIRE PROTECTION PROGRAM

REVIEW RESPONSIBILITIES

Primary - Chemical Engineering Branch (CMEB)

Secondary - None

I. AREAS OF REVIEW

The purpose of the fire protection program (FPP) is to provide assurance, through a defense-in-depth design, that a fire will not prevent the performance of necessary safe plant shutdown functions and will not significantly increase the risk of radioactive releases to the environment in accordance with General Design Criteria 3 and 5. The fire protection program consists of fire detection and extinguishing systems and equipment, administrative controls and procedures, and trained personnel.

The CMEB review of the fire protection program includes a review of the evaluation of potential fire hazards described in the applicant's Safety Analysis Report (SAR), and a review of the description of the fire protection system design showing the system characteristics and layout which define the "fire prevention" and "fire protection" portions of the program.

The CMEB reviews the total fire protection program described in the applicant's Safety Analysis Report (SAR) with respect to the criteria of Branch Technical Position CMEB 9.5-1 attached to this SRP section, specifically with respect to the following:

1. Overall fire protection program requirements, including the degree of involvement and assigned responsibility of management; fire protection administrative controls and quality assurance program; fire brigade training activities and coordination with offsite fire fighting organizations, including their capability in assisting in the extinguishment of plant fires.

2. Evaluation of potential fire hazards for safety-related areas throughout the plant and the effect of postulated fires relative to maintaining the ability

to perform safe shutdown functions, and minimizing radioactive releases to the environment.

3. Plant layout, egress routes, facility arrangements, and structural design features which control separation or isolation of redundant safety systems and selection of the methods for fire detection, control and extinguishing; control of fire hazards; fire barriers and walls; use of noncombustible materials; floor drains, ventilation, emergency lighting and communication systems.

4. The functional performance of the fire fighting systems, extinguishing agents, including the detection, alarm, suppression, control, and extinguishing systems described in the SAR to verify the adequacy of the FPP to protect safety-related equipment.

5. The fire protection system piping and instrumentation diagrams (P&IDs); including redundancy of equipment; the FPP design criteria and failure modes and effects analysis (impairment).

6. On multiple unit applications, the additional fire protection and control provisions during construction of the remaining units will be reviewed to verify that the integrity and operability of the fire protection system is maintained.

The CMEB will coordinate other branches' activities related to fire protection as follows:

The Auxiliary Systems Branch (ASB)* reviews the applicant's list of systems and components needed to provide safe shutdown capability and reviews the applicant's program for identification of the locations where redundant trains or divisions of safe shutdown systems are separated by less than 20 feet. The results of these reviews are provided to CMEB. CMEB notifies the applicant of results as appropriate and reviews the applicant's fire protection measures to deal with separation deficiencies. If such measures involve modifications of original system (including emergency lighting and communication) or circuit designs, or changes in layout of equipment, ASB* will review upon request from CMEB. The designs will be reviewed against the criteria for shutdown systems given in BTP CMEB 9.5-1, Positions C.5.b and C.5.c. The review of these modifications will be documented in SER sections dealing with the systems involved.

The Emergency Preparedness Licensing Branch (EPLB) will evaluate the adequacy of the offsite emergency planning as part of its primary review responsibility for SRP Section 13.3. The Licensing Qualification Branch (LQB) will evaluate the fire protection brigade training programs and will evaluate the organizational arrangements as part of its primary review responsibilities for SRP Sections 13.2.2 and 13.1, respectively. The Procedures and Test Review Branch (PTRB) will evaluate the fire protection plant procedures as part of its primary responsibility for SRP Section 13.5. The Quality Assurance Branch (QAB) will evaluate the adequacy of the QA Program as part of its primary review responsibility for SRP Section 17.0. The Licensing Guidance Branch will review the technical specifications prepared by the applicant for fire protection as part of its primary review responsibility for SRP Section 16.0. The Structural Engineering Branch (SEB) will, upon request, verify the acceptability of the

*With assistance from other PS branches (RSB, ICSB, PSB) as required.

design analyses, procedures, and criteria used for seismic Category I supporting structures for the FPP, and for externally imposed system loads resulting from less severe natural phenomena. The Mechanical Engineering Branch (MEB) will, upon request, review that portion of the hose standpipe system which should remain functional following a postulated SSE, and confirm that systems components, piping, and structures are designed in accordance with applicable seismic design criteria. The Instrumentation and Control Systems Branch (ICSB) verifies, on request, the adequacy of the fire protection instrumentation and controls.

For those areas of review identified above as being reviewed as part of the primary responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

The applicant's fire protection program is acceptable if it is in accordance with the following criteria:

1. 10 CFR Part 50 §50.48, and General Design Criterion 3, as related to fire prevention, the design and operation of fire detection and protection systems, and administrative controls provided to protect safety-related structures, systems, and components of the reactor facility.

2. General Design Criterion 5, as related to fire protection for shared safety-related structures, systems, and components to assure the ability to perform their intended safety function.

The following specific criteria provide information, recommendations, and guidance and in general describe a basis acceptable to the staff that may be used to meet the requirements of §50.48, GDC 3 and 5:

a. Branch Technical Position (BTP) CMEB 9.5-1 as it relates to the design provisions given to implement the fire protection program.

b. Regulatory Guide 1.78 as it relates to habitable areas such as the control room and to the use of specific fire extinguishing agents.

c. Regulatory Guide 1.101, as it relates to fire protection emergency planning.

III. REVIEW PROCEDURES

The secondary and coordinated review branches will provide input for the areas of review stated in subsection I of this SRP section. The primary reviewer obtains and uses such input as required to assure that this review procedure is complete.

The reviewer will select and emphasize material from this SRP section as may be appropriate for a particular case.

1. CMEB reviews the SAR to determine that the appropriate levels of management and trained, experienced personnel are responsible for the design and implementation of the fire protection program in accordance with BTP CMEB 9.5-1.

2. CMEB reviews the analysis in the SAR of the fire potential in safety-related plant areas and the hazard of fires to these areas to determine that the proposed fire protection program is able to maintain the ability to perform safe shutdown functions and to minimize radioactive releases to the environment.

3. CMEB reviews the FPP P&IDs and plant layout drawings to verify that facility arrangement, buildings, and structural and compartmentation features which affect the methods used for fire protection, fire control, and control of hazards are acceptable for the protection of safety-related equipment.

4. CMEB determines that design criteria and bases for the detection and suppression systems for smoke, heat and flame control are in accordance with the BTP guidelines and provide adequate protection for safety-related structures, systems, and components. The reviewer determines that fire protection support systems, such as emergency lighting and communication systems, floor drain systems, and ventilation and exhaust systems are designed to operate consistent with this objective. CMEB reviews the results of an FPP failure modes and effect analysis (impairment) to assure that the entire fire protection system for one safety-related area cannot be impaired by a single failure.

5. For multiple unit sites, CMEB determines that protection is provided to operating units during concurrent construction of other units. This includes an evaluation of the total fire protection program for each plant, the overall program for the site, including division of responsibility on fire protection matters.

6. CMEB reviews the technical specifications proposed by the applicant for fire protection (OL). The reviewer will determine that the limiting conditions for operation and surveillance requirements of the technical specifications are in agreement with the requirements developed as a result of the staff's review.

IV. EVALUATION FINDINGS

CMEB verifies that sufficient information has been provided and that the review is adequate to support conclusions of the following type, to be included in the staff's safety evaluation report:

> The staff concludes that the fire protection program's design criteria and bases are acceptable and meet the requirements of 10 CFR Part 50, §50.48 and General Design Criteria 3 and 5. This conclusion is based on the applicant meeting the guidelines of Branch Technical Position CMEB 9.5-1, and Regulatory Guides 1.78 and 1.101 as well as applicable industry standards. In meeting these guidelines the applicant has provided an acceptable basis for the design and location of safety-related structures and systems to minimize the probability and effect of fires and explosions; has used noncombustible and heat resistant materials whenever practical; has provided of fire detection and fire fighting systems of appropriate capacity and capability to minimize adverse effects of fire on safety-related systems. In addition, the applicant has demonstrated that shared structures, systems, and components of the fire protection systems will not prevent their ability to perform their intended safety functions.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 3, "Fire Protection."
2. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures, Systems, and Components."
3. Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release."
4. Regulatory Guide 1.101, "Emergency Planning for Nuclear Power Plants."
5. Branch Technical Position CMEB 9.5-1, "Guidelines for Fire Protection for Nuclear Power Plants."
6. 10 CFR Part 50, § 50.48, "Fire Protection."
7. Appendix R to 10 CFR Part 50, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979."

BRANCH TECHNICAL POSITION CMEB 9.5-1

(Formerly BTP ASB 9.5-1)

GUIDELINES FOR

FIRE PROTECTION FOR NUCLEAR POWER PLANTS

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A. INTRODUCTION

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

This Branch Technical Position (BTP) presents guidelines acceptable to the NRC staff for implementing this criterion in the development of a fire protection program for nuclear power plants. These revised guidelines include the acceptance criteria listed in a number of documents, including Appendix R to 10 CFR Part 50 and 10 CFR Part 50, § 50.48. The purpose of the fire protection program is to ensure the capability to shut down the reactor and maintain it in a safe shutdown condition and to minimize radioactive releases to the environment in the event of a fire. It implements the philosophy of defense-in-depth protection against the hazards of fire and its associated effects on safety-related equipment. If designs or methods different from the guidelines recommended herein are used, they must provide equivalent fire protection. Suitable bases and justification should be provided for alternative approaches to establish acceptable implementation of General Design Criterion 3.

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

B. DISCUSSION

There have been numerous fires in operating U.S. nuclear power plants through December 1975 of which 32 were important enough to report. Of these, the fire on March 22, 1975 at Browns Ferry nuclear plant was the most severe. With approximately 250 operating reactor years of experience, one may infer a frequency on the order of one fire per 10 reactor years. Thus, on the average, a nuclear power plant may experience one or more fires of varying severity during its operating life. Although WASH-1400, "Reactor Safety Study - An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," dated October 1975, concluded that the Browns Ferry fire did not affect the validity of the overall risk assessment, the staff concluded that cost-effective fire protection measures should be instituted to significantly decrease the frequency and severity of fires and consequently initiated the development of this BTP. In this development, the staff made use of many national standards and other publications related to fire protection. The documents discussed below were particularly useful.

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

The fire protection program for a nuclear power plant presented in this BTP consists of design features, personnel, equipment, and procedures that provide the defense-in-depth protection of the public health and safety. The purpose of the program is to prevent significant fires, to ensure the capability to shut down the reactor and maintain it in a safe shutdown condition, and to minimize radioactive releases to the environment in the event of a significant fire. To meet these objectives, it is essential that management participation in the program begin with early design concepts and plant layout work and continue through plant operation and that a qualified staff be responsible for engineering and design of fire protection features that provide fire detection, annunciation, confinement, and suppression for the plant. The staff should also be responsible for fire prevention activities, maintenance of fire protection systems, training, and manual firefighting activities. It is the combination of all these that provides the needed defense-in-depth protection of the public health and safety.

Some of the major conclusions that emerged from the Browns Ferry fire investigations warrant emphasis and are discussed below.

1. Defense-in-Depth

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

a. Preventing fires from starting;

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

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

No one of these echelons can be perfect or complete by itself. Each echelon should meet certain minimum requirements; however, strengthening any one can compensate in some measure for weaknesses, known or unknown, in the others.

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

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

2. Use of Water on Electrical Cable Fires

Experience with major electrical cable fires shows that water will promptly extinguish such fires. Since prompt extinguishing of the fire is vital to reactor safety, fire and water damage to safety systems is reduced by the more efficient application of water from fixed systems spraying directly on the fire rather than by manual application with fire hoses. Appropriate firefighting procedures and fire training should provide the techniques, equipment, and skills for the use of water in fighting electrical cable fires in nuclear plants, particularly in areas containing a high concentration of electric cables with plastic insulation.

This is not to say that fixed water systems should be installed everywhere. Equipment that may be damaged by water should be shielded or relocated away from the fire hazard and the water. Drains should be provided to remove any water used for fire suppression and extinguishment to ensure that water accumulation does not incapacitate safety-related equipment.

3. Establishment and Use of Fire Areas

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

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

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

4. Definitions

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

Approved - tested and accepted for a specific purpose or application by a nationally recognized testing laboratory.

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

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

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

Exposure Fire - An exposure fire is a fire in a given area that involves either in situ or transient combustibles and is external to any structures, systems, or 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, or components important to safety. Thus, a fire involving one train of safe shutdown equipment may constitute an exposure fire for the redundant train located in the same area, and a fire involving combustibles other than either redundant train may constitute an exposure fire to both redundant trains located in the same area.

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

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

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

Fire Brigade - the team of plant personnel assigned to firefighting and who are equipped for and trained in the fighting of fires.

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

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

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

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

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

Fire Protection Program - the integrated effort involving components, procedures, and personnel utilized in carrying out all activities of fire protection. It includes system and facility design, fire prevention, fire detection, annunciation, confinement, suppression, administrative controls, fire brigade organization, inspection and maintenance, training, quality assurance, and testing.

Fire Resistance Rating - The time that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of "Standard Methods of Fire Tests of Building Construction and Materials" (NFPA 251).

Fire Suppression - control and extinguishing of fires (firefighting). Manual fire suppression is the use of hoses, portable extinguishers, or manually-actuated fixed systems by plant personnel. Automatic fire suppression is the use of automatically actuated fixed systems such as water, Halon, or carbon dioxide systems.

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

Noncombustible Material

a. A material which in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.

b. Material having a structural base of noncombustible material, as defined in a., above, with a surfacing not over 1/8-inch thick that has a flame spread rating not higher than 50 when measured using ASTM E-84 Test "Surface Burning Characteristics of Building Materials."

Raceway - refer to Regulatory Guide 1.75.

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

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

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

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

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

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

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

C. POSITION

1. Fire Protection Program Requirements

a. Fire Protection Program

A fire protection program should be established at each nuclear power plant. The program should establish the fire protection policy for the protection of structures, systems, and components important to safety at each plant and the procedures, equipment, and personnel required to implement the program at the plant site.

(1) 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.

(2) 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.

(3) 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 balanced approach in directing the fire protection program for the nuclear power plant.

The staff should be responsible for:

(a) Fire protection program requirements, including consideration of potential hazards associated with postulated fires, with knowledge of building layout and systems design.

(b) Post-fire shutdown capability.

(c) Design, maintenance, surveillance, and quality assurance of all fire protection features (e.g., detection systems, suppression systems, barriers, dampers, doors, penetration seals, and fire brigade equipment).

(d) Fire prevention activities (administrative controls and training).

(e) Fire brigade organization and training.

(f) Prefire planning.

(4) The organizational responsibilities and lines of communication pertaining to fire protection should be defined between the various positions through the use of organizational charts and functional descriptions of each position's responsibilities. The following positions/organizations should be designated:

(a) The upper level offsite managment position which has management responsibility for the formulation, implementation, and assessment of the effectiveness of the nuclear plant fire protection program.

(b) The offsite management position(s) 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 which include the fire protection and prevention program and which provide a single point of control and contact for all contingencies.

(d) The onsite position(s) which:

i. Implements periodic inspections to: minimize the amount of combustibles in safety-related areas; determine the effectiveness of housekeeping practices; assure 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 assures the prompt and effective corrective actions are taken to correct conditions adverse to fire protection and preclude their recurrence.

ii. Is responsible for the fire fighting 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 evaluate test results and determine the acceptability of the systems under test.

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

iv. Reviews and evaluates proposed work activities to identify potential transient fire loads.

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

vi. Implements 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.

(e) The onsite position responsible for fire protection quality assurance. This position should be responsible for assuring the effective implementation of the fire protection program by planned inspections, scheduled audits, and verification that the results of these inspections of audits are promptly reported to cognizant management personnel.

(f) The positions which are part of the plant fire brigade:

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 fire fighting procedures.

iii. The responsibilities of the fire brigade members under normal plant conditions should not conflict with their responsibilities 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 the most significant fire. The size of the fire brigade should be based upon the functions required to fight fires with adequate allowance for injuries.

v. The recommendations for organization, training, and equipment of "Private Fire Brigades" as specified in NFPA No. 27-1975, including the applicable NFPA publications listed in the appendix to NFPA No. 27, are considered appropriate criteria for organizing, training, and operating a plant fire brigade.

(5) Personnel Qualifications

(a) The position responsible for formulation and implementation of the fire protection program should have within his organization or as a consultant a fire protection engineer who is a graduate of an engineering curriculum of accepted standing and shall have completed not less than 6 years of engineering attainment indicative of growth in engineering competency and achievement, 3 years of which shall have been in responsible charge of fire protection engineering work. These requirements are the eligibility requirements as a Member in the Society of Fire Protection Engineers.

(b) The fire brigade members' qualifications should include satisfactory completion of a physical examination for performing strenuous activity, and of the fire brigade training described in Position C.3.d.

(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 training and experience for such work.

(6) The following NFPA publications should be used for guidance to develop the fire protection program:

No. 4 - "Organization for Fire Services"
No. 4A - "Organization of a Fire Department"
No. 6 - "Industrial Fire Loss Prevention"
No. 7 - "Management of Fire Emergencies"
No. 8 - "Management Responsibilities for Effects of Fire on Operations"
No. 27 - "Private Fire Brigades"

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

b. Fire Hazards Analysis

The fire hazards analysis should demonstrate that the plant will maintain the ability to perform safe shutdown functions and minimize radioactive releases to the environment in the event of a fire.

The fire hazards analysis should be performed by qualified fire protection and reactor systems engineers to (1) consider potential in situ and transient fire hazards; (2) determine 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 (3) specify measures for fire prevention, fire detection, fire suppression, and fire containment and alternative shutdown capability as required for each fire area containing structures, systems, and components important to safety that are in conformance with NRC guidelines and regulations.

"Worst case" fires need not be postulated to be simultaneous with nonfire-related failures in safety systems, 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 due to 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.

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 postfire 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. Three levels of fire damage limits are established according to the safety function of the structure, system, or component:

Safety Function	Fire Damage Limits
Hot shutdown	One train of equipment necessary to achieve hot shutdown from either the control room or emergency control station(s) must be maintained free of fire damage by a single fire, including an exposure fire.
Cold shutdown	Both trains of equipment necessary to achieve cold shutdown may be damaged by a single fire, including an exposure fire, but damage must be limited so that at least one train can be repaired or made operable within 72 hours using onsite capability.
Design basis accidents	Both trains of equipment necessary for mitigation of consequences following design basis accidents may be damaged by a single exposure fire.

The most stringent fire damage limit should apply for those systems that fall into more than one category. Redundant systems used to mitigate the consequences of other design basis accidents but not necessary for safe shutdown may be lost to a single exposure fire. However, protection shall be provided so that a fire within only one such system will not damage the redundant system.

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

(1) Concentrations of combustible contents, including transient fire loads due to 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) Exposure fire, heat, smoke, or water exposure, 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 safety-related functions;

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

(6) Lack of explosion-prevention measures;

(7) Loss of electric power or control circuits;

(8) Inadvertent operation of fire suppression systems.

The fire hazards analysis should verify that the NRC fire protection program guidelines have been met. The analysis should list 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. Deletion of a protective feature without compensating alternative protection measures will not be acceptable, unless it is clearly demonstrated that the protective measure is not needed because of the design and arrangement of the particular plant.

c. Fire Suppression System Design Basis

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

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

(3) As a minimum, the fire suppression system should be capable of delivering water to manual hose stations located within hose reach of areas containing equipment required for safe plant shutdown following the safe shutdown earthquake (SSE). In areas of high seismic activity, the staff will

consider on a case-by-case basis the need to design the fire detection and suppression systems to be functional following the SSE.

(4) The fire protection systems should retain their original design capability for (a) natural phenomena of less severity and greater frequency than the most severe natural phenomena (approximately once in 10 years) such as tornadoes, hurricanes, floods, ice storms, or small-intensity earthquakes that are characteristic of the geographic region, and (b) potential man-made site-related events such as oil barge collisions or aircraft crashes that have a reasonable probability of occurring at a specific plant site. The effects of lightning strikes should be included in the overall plant fire protection program.

(5) The consequences of inadvertent operation of or a crack in a moderate energy line in the fire suppression system should meet the guidelines specified for moderate-energy systems outside containment in SRP Section 3.6.1.

d. Alternative or Dedicated Shutdown

Alternative or dedicated shutdown capability should be provided where the protection of systems whose functions are required for safe shutdown is not provided by established fire suppression methods or by Position C.5.6.

e. Implementation of Fire Protection Programs

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

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

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

2. Administrative Controls

Administrative controls should be used to maintain the performance of the fire protection system and personnel. These controls should establish procedures to:

a. Prohibit bulk storage of combustible materials inside or adjacent to safety-related buildings or systems during operation or maintenance periods. Regulatory Guide 1.39 provides guidance on housekeeping, including the disposal of combustible materials.

b. Govern the handling and limitation of the use of ordinary combustible materials, combustible and flammable gases and liquids, high efficiency particulate air and charcoal filters, dry ion exchange resins, or other combustible supplies in safety-related areas.

c. Govern the handling of and limit transient fire loads such as combustible and flammable liquids, wood and plastic products, or other combustible materials in buildings containing safety-related systems or equipment during all phases of operating, and especially during maintenance, modification, or refueling operations.

d. Designate the onsite staff member responsible for the inplant fire protection review of proposed work activities to identify potential transient fire hazards and specify required additional fire protection in the work activity procedure.

e. Govern the use of ignition sources by use of a flame permit system to control welding, flame 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.

f. Control the removal from the area of all waste, debris, scrap, oil spills, or other combustibles resulting from the work activity immediately following completion of the activity, or at the end of each work shift, whichever comes first.

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

h. Maintain the periodic housekeeping inspections to ensure continued compliance with these administrative controls.

i. Control the use of specific combustibles in safety-related areas. All wood used in safety-related areas during maintenance, modification, or refueling operation (such as lay-down blocks or scaffolding) should be treated with a flame retardant. Equipment or supplies (such as new fuel) shipped in untreated combustible packing containers may be unpacked in safety-related areas 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 during lunch breaks, shift changes, or other similar periods. 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.

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

k. Successful fire protection requires testing and maintenance of the fire protection equipment and the emergency lighting and communication. A test plant that lists the individuals and their responsibilities in connection with routine tests and inspections of the fire detection and protection systems should be developed. The test plan should contain the types, frequency, and detailed procedures for testing. Procedures should also contain instructions on maintaining fire protection during those periods when the fire protection system is impaired or during periods of plant maintenance, e.g., fire watches or temporary hose connections to water systems.

l. Control actions to be taken by an individual discovering a fire, for example, notification of control room, attempt to extinguish fire, and actuation of local fire suppression systems.

m. Control actions to be taken by the control room operator to determine the need for brigade assistance upon report of a fire or receipt of alarm on control room annunciator panel, for example, announcing location of fire over PA system, sounding fire alarms, and notifying the shift supervisor and the fire brigade leader of the type, size, and location of the fire.

n. Control actions to be taken by the fire brigade after notification by the control room operator of a fire, for example, assembling in a designated location, receiving directions from the fire brigade leader, and discharging specific fire fighting responsibilities, including selection and transportation of fire fighting equipment to 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.

o. Define the strategies for fighting fires in all safety-related areas and areas presenting a hazard to safety-related equipment. These strategies should designate:

(1) Fire hazards in each area covered by the specific prefire plans.

(2) Fire extinguishants best suited for controlling the fires associated with the fire hazards in that area and the nearest location of these extinguishants.

(3) 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.

(4) 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 fire fighting procedure that could increase the hazards in the area because of overpressurization or electrical hazards).

(5) Vital heat-sensitive system components that need to be kept cool while fighting a local fire. Particularly hazardous combustibles that need cooling should be designated.

(6) Organization of fire fighting brigades and the assignment of special duties according to job title so that all fire fighting 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 extinguishant

to the fire, communication with the control room, and coordination with outside fire departments.

(7) Potential radiological and toxic hazards in fire zones.

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

(9) Operations requiring control room and shift engineer coordination or authorization.

(10) Instructions for plant operators and general plant personnel during fire.

3. Fire Brigade

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

b. A site fire brigade trained and equipped for fire fighting should be established to ensure adequate manual fire fighting capability for all areas of the plant containing structures, systems, or components important to safety. The fire brigade should be at least five members on each shift. The brigade leader and at least two brigade members should have sufficient training in or knowledge of plant safety-related systems to understand the effects of fire and fire suppressants on safe shutdown capability. The qualification of fire brigade members should include an annual physical examination to determine their ability to perform strenuous fire fighting activities. The shift supervisor should not be a member of the fire brigade. The brigade leader shall 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 safety-related systems.

c. The minimum equipment provided for the brigade should consist of personal protective equipment such as turnout coats, 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 shall 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 shall be a minimum of one-half hour for the self-contained units.

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

d. The fire brigade training program shall ensure that the capability to fight potential fires is established and maintained. The program shall consist of an initial classroom instruction program followed by periodic classroom instruction, fire fighting practice, and fire drills.

(1) The initial classroom instruction should include:

(a) Indoctrination of the plant fire fighting 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 fire fighting 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 fire fighting equipment and the corrective method of fighting each type of fire. The types of fires covered should include 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 modification (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 fire fighting activities (fire brigade leaders only).

(i) Detailed review of fire fighting strategies and procedures.

(j) Review of the latest plant modifications and corresponding changes in fire fighting plans.

(k) 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.

(l) Local fire departments should be provided training in operational precautions when fighting fires on nuclear power plant sites and should be made aware of the need for radiological protection of personnel and the special hazards associated with a nuclear power plant site.

Note: Items (i) and (j) may be deleted from the training of no more than two of the nonoperations personnel who may be assigned to the fire brigade.

(2) 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.

(3) Instruction should be provided to all fire brigade members and fire brigade leaders.

(4) Regular planned meetings should be held at least every 3 months for all brigade members to review changes in the fire protection program and other subjects as necessary.

(5) Periodic refresher training sessions shall be held to repeat the classroom instruction program for all brigade members over a 2-year period. These sessions may be concurrent with the regular planned meetings.

(6) Practice

(a) 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 shall provide brigade members with experience in actual fire extinguishment and the use of emergency breathing apparatus under strenuous conditions encountered in fire fighting.

(b) These practice sessions should be provided at least once per year for each fire brigade member.

(7) Drills

(a) Fire brigade drills should be performed in the plant so that the fire brigade can practice as a team.

(b) Drills should be performed at regular intervals not to exceed 3 months for each shift fire brigade. Each fire brigade member should participate in each drill, but must 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 fire fighting 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 is begun. Unannounced drills should not be scheduled closer than 4 weeks.

At least one drill per year should be performed on a "back shift" for each shift fire brigade.

(c) 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.

(d) These drills should provide for local fire department participation periodically (at least annually).

(e) 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.

(f) Drills should as a minimum include the following:

i. Assessment of fire alarm effectiveness, time required to notify and assemble fire brigade, and selection, placement, and use of equipment and fire fighting strategies.

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

iii. The simulated use of fire fighting 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 due to the time required to respond, to obtain equipment, and organize for the fire, assuming loss of automatic suppression capability.

iv. Assessment of brigade leader's direction of the fire fighting effort as to thoroughness, accuracy, and effectiveness.

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

(9) Guidance Documents

NFPA 27, "Private Fire Brigade," should be followed in organization, training, and fire drills. This standard also is applicable for the inspection and maintenance of fire fighting equipment. Among the standards referenced in this document, NFPA 197, "Training Standard on Initial Fire Attacks," should be utilized as applicable. NFPA booklets and pamphlets listed in NFPA 27 may be used as applicable for training references. In addition, courses in fire prevention and fire suppression that are recognized or sponsored by the fire protection industry should be utilized.

4. Quality Assurance Program

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

a. Design and Procurement Document Control

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

b. Instructions, Procedures, and Drawings

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

c. Control of Purchased Material, Equipment, and Services

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

d. Inspection

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

e. Test and Test Control

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

f. Inspection, Test, and Operating Status

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

g. Nonconforming Items

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

h. Corrective Action

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

i. Records

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

j. Audits

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

5. General Plant Guidelines

a. Building Design

(1) Fire barriers with a minimum fire resistance rating of 3 hours should be provided to:

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

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

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

(2) Appropriate fire barriers should be provided within a single safety division to separate components that present a fire hazard to other safety-related

components or high concentrations of safety-related cables within that division.

(3) Openings through fire barriers for pipe, conduit, and cable trays which 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 4 inches in diameter should be sealed at the fire barrier penetration. Openings inside conduit 4 inches or less in diameter should be sealed at the fire barrier unless the conduit extends at least 5 feet on each side of the fire barrier and is sealed either at both ends or at the fire barrier with noncombustible material to prevent the passage of smoke and hot gases. Fire barrier penetrations that must maintain environmental isolation or pressure differentials should be qualified by test to maintain the barrier integrity under such conditions.

Penetration designs should utilize only noncombustible materials and should be qualified by tests. The penetration qualification tests should use the time-temperature exposure curve specified by ASTM E-119, "Fire Test of Building Construction and Materials." The acceptance criteria for the test should require that:

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

(b) The temperature levels recorded for the unexposed side are analyzed and demonstrate that the maximum temperature does not exceed 325°F.

(c) The fire barrier penetration remains intact and does not allow projection of water beyond the unexposed surface during the hose stream test. The stream shall be delivered through a 1-1/2-inch nozzle set at a discharge angle of 30% with a nozzle pressure of 75 psi and a minimum discharge of 75 gpm with the tip of the nozzle a maximum of 5 ft from the exposed face; or the stream shall be delivered through a 1-1/2-inch nozzle set at a discharge angle of 15% with a nozzle pressure of 75 psi and a minimum discharge of 75 gpm with the tip of the nozzle a maximum of 10 ft from the exposed face; or the stream shall be delivered through a 2-1/2-inch national standard playpipe equipped with 1-1/8-inch tip, nozzle pressure of 30 psi, located 20 ft from the exposed face.

(4) Penetration openings for ventilation systems should be protected by fire dampers having a rating equivalent to that required of the barrier (see NFPA-90A, "Air Conditioning and Ventilating Systems"). Flexible air duct coupling in ventilation and filter systems should be noncombustible.

(5) Door openings in fire barriers should be protected with equivalently rated doors, frames, and hardware that have been tested and approved by a nationally recognized laboratory. Such doors should be 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. (See NFPA 80, "Fire Doors and Windows.")

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.

The fire brigade leader should have ready access to keys for any locked fire doors.

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

(6) Personnel access routes and escape routes should be provided for each fire area. Stairwells outside primary containment serving as escape routes, access routes for firefighting, or access routes to areas containing equipment necessary for safe shutdown should be enclosed in masonry or concrete towers with a minimum fire rating of 2 hours and self-closing Class B fire doors.

(7) Fire exist routes should be clearly marked.

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

(9) Interior wall and structural components, thermal insulation materials, radiation shielding materials, and soundproofing should be noncombustible. Interior finishes should be non-combustible.

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

- Plaster, acoustic plaster, gypsum plasterboard (gypsum wallboard), 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;
- Vinyl tile, vinyl-asbestos tile, linoleum, or asphalt tile on concrete floors.

(10) 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 System Approval Guide.

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

(12) Transformers installed inside fire areas containing safety-related systems 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 (see Section 450(c) of NFPA 70, "National Electrical Code").

(13) Outdoor oil-filled transformers should have oil spill confinement features or drainage away from the buildings. Such transformers should be located at least 50 feet distant from the building, or by ensuring that such building walls within 50 feet of oil-filled transformers are without openings and have a fire resistance rating of at least 3 hours.

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

b. Safe Shutdown Capability

(1) Fire protection features should be provided for structures, systems, and components important to safe shutdown. These features should be capable of limiting fire damage so that:

(a) One train of systems necessary to achieve and maintain hot shutdown conditions from either the control room or emergency control station(s) is free of fire damage; and

(b) Systems necessary to achieve and maintain cold shutdown from either the control room or emergency control station(s) can be repaired within 72 hours.

(2) To meet the guidelines of Position C5.b.1, one of the following means of ensuring that one of the redundant trains is free of fire damage should be provided:

(a) Separation of cables and equipment and associated circuits of redundant trains by a fire barrier having a 3-hour rating. Structural steel forming a part of or supporting such fire barriers should be protected to provide fire resistance equivalent to that required of the barrier;

(b) Separation of cables and equipment and associated circuits of redundant trains by a horizontal distance of more than 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; or

(c) Enclosure of cable and equipment and associated circuits of one redundant train 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.

(3) If the guidelines of Positions C5.b.1 and C5.b.2 cannot be met, then alternative or dedicated shutdown capability and its associated circuits, independent of cables, systems or components in the area, room, or zone under consideration should be provided.

c. Alternative or Dedicated Shutdown Capability

(1) Alternative or dedicated shutdown capability provided for a specific fire area should be able to achieve and maintain subcritical reactivity conditions in the reactor, maintain reactor coolant inventory, achieve and maintain hot standby* conditions for a PWR (hot shutdown* for a BWR) and achieve cold shutdown* conditions within 72 hours and maintain cold shutdown conditions thereafter. During the postfire shutdown, the reactor coolant system process variables shall be maintained within those predicted for a loss of normal ac power, and the fission product boundary integrity shall not be affected; i.e., there shall be no fuel clad damage, rupture, or any primary coolant boundary, or rupture of the containment boundary.

(2) The performance goals for the shutdown functions should be:

(a) The reactivity control function should be capable of achieving and maintaining cold shutdown reactivity conditions.

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

(c) The reactor heat removal function should be capable of achieving and maintaining decay heat removal.

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

(e) 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.

*As defined in the Standard Technical Specifications.

(3) The 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 shall be independent of the specific fire area(s) and shall accommodate postfire conditions where offsite power is available and where offsite power is not available for 72 hours. Procedures shall be in effect to implement this capability.

(4) If the capability to achieve and maintain cold shutdown will not be available because of fire damage, the equipment and systems comprising the means to achieve and maintain the hot standby or hot shutdown condition shall be capable of maintaining such conditions until cold shutdown can be achieved. If such equipment and systems will not be capable of being powered by both onsite and offsite electric power systems because of fire damage, an independent onsite power system shall be provided. The number of operating shift personnel, exclusive of fire brigade members, required to operate such equipment and systems shall be onsite at all times.

(5) Equipment and systems comprising 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. Materials for such repairs shall be readily available onsite and procedures shall be in effect to implement such repairs. If such equipment and systems used prior to 72 hours after the fire will not be capable of being powered by both onsite and offsite electric power systems because of fire damage, an independent onsite power system should be provided. Equipment and systems used after 72 hours may be powered by offsite power only.

(6) Shutdown systems installed to ensure postfire shutdown capability need not be designed to meet seismic Category I criteria, single failure criteria, or other design basis accident criteria, except where required for other reasons, e.g., because of interface with or impact on existing safety systems, or because of adverse valve actions due to fire damage.

(7) The safe shutdown equipment and systems for each fire area should be known to be isolated from associated circuits in the fire area so that hot shorts, open circuits, or shorts to ground in the associated circuits will not prevent operation of the safe shutdown equipment. The separation and barriers between trays and conduits containing associated circuits of one safe shutdown division and trays and conduits containing associated circuits or safe shutdown cables from the redundant division, or the isolation of these associated circuits from the safe shutdown equipment, should be such that a postulated fire involving associated circuits will not prevent safe shutdown.

d. Control of Combustibles

(1) Safety-related systems should be isolated or separated from combustible materials. When this is not possible because of the nature of the safety system or the combustible material, special protection should be provided to prevent a fire from defeating the safety system function. Such protection may involve a combination of automatic fire suppression, and construction capable of withstanding and containing a fire that consumes all combustibles present. Examples of such combustible materials that may not be separable from the remainder of its system are:

(a) Emergency diesel generator fuel oil day tanks.

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

(c) Reactor coolant pump lube oil system.

(2) Bulk gas storage (either compressed or cryogenic), should not be permitted inside structures housing safety-related equipment. Storage of flammable gas such as hydrogen should be located outdoors or in separate detached buildings so that a fire or explosion will not adversely affect any safety-related systems or equipment. (Refer to NFPA 50A, "Gaseous Hydrogen Systems.")

Care should be taken to locate high pressure gas storage containers with the long axis parallel to building walls. This will minimize the possibility of wall penetration in the event of a container failure. Use of compressed gases (especially flammable and fuel gases) inside buildings should be controlled. (Refer to NFPA 6, "Industrial Fire Loss Prevention.")

(3) The use of plastic materials should be minimized. In particular, halogenated plastics such as polyvinyl chloride (PVC) and neoprene should be used only when substitute noncombustible materials are not available. All plastic materials, including flame and fire retardant materials, will burn with an intensity and BTU production in a range similar to that of ordinary hydrocarbons. When burning, they produce heavy smoke that obscures visibility and can plug air filters, especially charcoal and HEPA. The halogenated plastics also release free chlorine and hydrogen chloride when burning which are toxic to humans and corrosive to equipment.

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

(5) Hydrogen lines in safety-related areas should be either designed to seismic Class I requirements, or sleeved such that the water pipe is directly vented to the outside, or should be equipped with excess flow valves so that in case of a line break, the hydrogen concentration in the affected areas will not exceed 2%.

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

(1) Only metal should be used for cable trays. Only metallic tubing should be used for conduit. Thin-wall metallic tubing should not be used. Flexible metallic tubing should only be used in short lengths to connect components to equipment. Other raceways should be made of noncombustible material

(2) Redundant safety-related cable systems outside the cable spreading room should be separated from each other and from potential fire exposure hazards in nonsafety-related areas by fire barriers with a minimum fire rating of 3 hours. These cable trays should be provided with continuous line-type heat detectors and should be accessible for manual firefighting. Cables should be designed to allow wetting down with fire suppression water without electrical faulting. Manual hose stations and portable hand extinguishers should be provided.

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

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

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

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

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

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

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

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

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

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

f. Ventilation

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

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

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

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

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

(6) Stairwells should be designed to minimize smoke infiltration during a fire.

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

g. Lighting and Communication

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

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

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

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

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

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

6. Fire Detection and Suppression

a. Fire Detection

(1) Detection systems should be provided for all areas that contain or present a fire exposure to safety-related equipment.

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

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

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

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

(6) Primary and secondary power supplies should be provided for the fire detection system and for electrically operated control valves for automatic suppression systems. Such primary and secondary power supplies should satisfy provisions of Section 2220 of NFPA 72D. This can be accomplished by 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 guidelines in Regulatory Guides 1.6, 1.32, and 1.75.

b. Fire Protection Water Supply Systems

(1) An underground yard fire main loop should be installed to furnish anticipated water requirements. NFPA 24, "Standard for Outside Protection," gives necessary guidance for such installation. It references other design codes and standards developed by such organizations as the American National Standards Institute (ANSI) and the American Water Works Association (AWWA). Type of pipe and water treatment should be design considerations with tuberculation as one of the parameters. Means for inspecting and flushing the systems should be provided.

(2) Approved visually indicating sectional control valves such as post-indicator valves should be provided to isolate portions of the main for maintenance or repair without shutting off the supply to primary and backup fire suppression systems serving areas that contain or expose safety-related equipment.

(3) Valves should be 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 safety-related or safe shutdown equipment.

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

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

(6) If pumps are required to meet system pressure or flow requirements, a sufficient number of pumps should be provided to ensure that 100% capacity will be available assuming failure of the largest pump or loss of offsite power (e.g., three 50% pumps or two 100% pumps). This can be accomplished, for example, by providing either:

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

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

Individual fire pump connections to the yard fire main loop should be separated with sectionalizing valves between connections. Each pump and its driver and controls should be located in a room separated from the remaining fire pumps by a fire wall with a minimum rating of 3 hours. The fuel for the diesel fire pump(s) should be separated so that it does not provide a fire source exposing safety-related equipment. Alarms indicating pump running, driver availability, failure to start, and low fire-main pressure should be provided in the control room.

The fire pump installation should conform to NFPA 20, "Standard for the Installation of Centrifugal Fire Pumps."

(7) Outside manual hose installation should be sufficient to provide an effective hose stream to any onsite location where fixed or transient combustibles could jeopardize safety-related equipment. Hydrants should be installed approximately every 250 ft on the yard main system. A hose house equipped with hose and combination nozzle and other auxiliary equipment recommended in NFPA 24, "Outside Protection," should be provided as needed, but at least every 1,000 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.

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

(9) Two separate, reliable freshwater supplies should be provided. Saltwater or brackish water should not be used unless all freshwater supplies have been exhausted. If tanks are used, two 100% (minimum of 300,000 gallons each) system capacity tanks should be installed. They should be so interconnected that pumps can take suction from either or both. However, a 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.

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

(11) 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 300,000 gallons. This flow rate should be based (conservatively) on 500 gpm for manual hose streams plus the largest design demand of any sprinkler or deluge system as determined in accordance with NFPA 13 or NFPA 15. The fire water supply should be capable of delivering this design demand over the longest route of the water supply system.

(12) Freshwater lakes or ponds of sufficient size may qualify as 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.

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

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

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

(14) 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.

c. Water Sprinkler and Hose Standpipe Systems

(1) Sprinkler systems and manual hose station standpipes should have connections to the plant underground water main so that a single active failure or a crack in a moderate-energy line 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 ANSI B31.1, "Power Piping," are used for the headers up to and including the first valve supplying the sprinkler systems where such headers are part of the seismically analyzed hose standpipe system. When provided, such headers are considered an extension of the yard main system. Each sprinkler and standpipe system should be equipped with OS&Y (outside screw and yoke) gate valve or other approved shutoff valve and waterflow alarm. Safety-related equipment that does not itself require sprinkler water fire protection but is subject to unacceptable damage if wet by sprinkler water discharge should be protected by water shields or baffles.

(2) Control and sectionalizing valves in the fire water systems should be electrically supervised or administratively controlled. The electrical supervision signal should indicate in the control room. All valves in the fire protection system should be periodically checked to verify position (see NFPA 26, "Supervision of Valves").

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

(4) Interior manual hose installation should be able to reach any location that contains, or could present a fire exposure hazard to, safety-related equipment with at least one effective hose stream. To accomplish this, standpipes with hose connections equipped with a maximum of 100 feet of 1-1/2-inch woven-jacket, lined fire hose and suitable nozzles should be provided in all buildings on all floors. Individual standpipes should be at least 4 inches in diameter for multiple hose connections and 2-1/2 inches in diameter for single hose connections. These systems should follow the requirements of NFPA 14, "Standpipe and Hose Systems," for sizing, spacing, and pipe support requirements.

Hose stations should be located as dictated by the fire hazard analysis to facilitate access and use for firefighting operations. Alternative hose stations should be provided for an area if the fire hazard could block access to a single hose station serving that area.

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

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

(6) Fire hose should be hydrostatically tested in accordance with the recommendations of NFPA 1962, "Fire Hose - Care, Use, Maintenance." Hose stored in outside hose houses should be tested annually. Interior standpipe hose should be tested every 3 years.

(7) Certain fires, such as those involving flammable liquids, respond well to foam suppression. Consideration should be given to use of mechanical low-expansion foam systems, high-expansion foam generators, or aqueous film-forming foam (AFFF) systems, including the AFFF deluge system. These systems should comply with the requirements of NFPA 11, NFPA 11A, NFPA 11B, and NFPA 16, as applicable.

d. Halon Suppression Systems

Halon fire extinguishing systems should comply with the requirements of NFPA 12A and NFPA 12B, "Halogenated Fire Extinguishing Agent Systems - Halon 1301 and Halon 1211." Only UL-listed or FM-approved agents should be used. Provisions for locally disarming automatic Halon systems should be key locked and under strict administrative control. Automatic Halon extinguishing systems should not be disarmed unless controls as described in Position C.2.c. are provided.

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

Particular consideration should also be given to:

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

(2) Toxicity of Halon;

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

(4) Location and selection of the activating detectors.

e. Carbon Dioxide Suppression Systems

Carbon dioxide extinguishing systems should comply with the requirements of NFPA 12, "Carbon Dioxide Extinguishing Systems." Where automatic carbon dioxide systems are used, they should be equipped with a predischarge alarm system and a discharge delay to permit personnel egress. Provisions for locally disarming automatic carbon dioxide systems should be key locked and under strict administrative control. Automatic carbon dioxide extinguishing systems should not be disarmed unless controls as described in Position C.2.c. are provided.

Particular consideration should also be given to:

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

(2) Anoxia and toxicity of CO_2;

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

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

(5) Location and selection of the activating detectors.

f. Portable Extinguishers

Fire extinguishers should be provided in areas that contain, or could present a fire exposure hazard to, safety-related equipment in accordance with guidelines of NFPA 10, "Portable Fire Extinguishers, Installation, Maintenance and Use." Dry chemical extinguishers should be installed with due consideration given to possible adverse effects on safety-related equipment installed in the area.

7. Guidelines for Specific Plant Areas

a. Primary and Secondary Containment

(1) Normal Operation - Fire protection requirements for the primary and secondary containment areas should be provided for hazards identified by the fire hazards analysis.

Examples of such hazards include lubricating oil or hydraulic fluid system for the primary coolant pumps, cable tray arrangements and cable penetrations, and charcoal filters. Because of the general inaccessibility of primary containment during normal plant operation, protection should be provided by automatic fixed systems. The effects of postulated fires within the primary containment should be evaluated to ensure that the integrity of the primary coolant system and the containment is not jeopardized assuming no action is taken to fight the fire.

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

(b) Inside noninerted containment one of the fire protection means stated in Positions C.5.b.1 and C.5.b.2 or the following fire protection means should be provided: separation of cables and equipment and associated nonsafety circuits of redundant trains by a noncombustible radiant energy shield having a minimum fire rating of one-half hour.

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

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

(d) Standpipe and hose stations should be 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 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 General Design Criterion 56 and should be seismic Category I and Quality Group B.

(e) The reactor coolant pumps 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 reactor coolant pump 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 flash point characteristics of the oil present the hazard of fire flashback. Leakage points to be protected should include 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 reactor coolant pumps. The drain line should be large enough to accommodate the largest potential oil leak.

(f) For secondary containment areas, cable fire hazards that could affect safety should be protected as described in Position C.5.e(2). The type of detection system for other fire hazards identified by the fire hazards analysis should be the most suitable for the particular type of fire hazard.

(2) Refueling and Maintenance --Refueling and maintenance operations in containment may introduce additional hazards such as contamination control materials, decontamination supplies, wood planking, temporary wiring, welding, and flame cutting (with portable compressed-gas fuel supply). Possible fires would not necessarily be in the vicinity of fixed detection and suppression systems. Management procedures and controls necessary to ensure adequate fire protection for transient fire loads are discussed in Position C.1.

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

b. Control Room Complex

The control room complex (including galleys, office spaces, etc.) should be protected against disabling fire damage and should be separated from other areas of the plant by floors, walls, and roof having minimum fire resistance ratings of 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 halon flooding system is used for fire suppression, these dampers should be strong enough to support the pressure rise accompanying halon discharge and seal tightly against infiltration of halon into the control room. Carbon dioxide flooding systems are not acceptable for these areas.

Manual firefighting capability should be provided for both:

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

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

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

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

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

Breathing apparatus for control room operators should be readily available.

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

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

All cables that enter the control room should terminate in the control room. That is, no cabling should be routed through the control room from one area to another. Cables in underfloor and ceiling spaces should meet the separation criteria necessary for fire protection.

Air-handling functions should be ducted separately from cable runs in such spaces; i.e., if cables are routed in underfloor or ceiling spaces, these spaces should not be used as air plenums for ventilation of the control room. Fully enclosed electrical raceways located in such underfloor and ceiling spaces, if over 1 square foot in cross-sectional area, should have automatic fire suppression inside. Area automatic fire suppression should be provided for underfloor and ceiling spaces if used for cable runs unless all cable is run in 4-inch or smaller steel conduit or the cables are in fully enclosed raceways internally protected by automatic fire suppression.

There should be no carpeting in the control room.

c. Cable Spreading Room

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

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

The use of foam is acceptable.

Cable spreading rooms should have:

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

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

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

(4) Area smoke detection; and

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

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

A separate cable spreading room should be provided for each redundant division. Cable spreading rooms should not be shared between reactors. Each cable spreading room should be separated from the others and from other areas of the plant by barriers with a minimum fire rating of 3 hours. If this is not possible, a dedicated system should be provided.

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

d. Plant Computer Rooms

Computer rooms for computers performing safety-related functions that are not part of the control room complex should be separated from other areas of the plant by barriers having a minimum fire resistance rating of 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 Position C.7.b. Computer cabinets located in the control room should be protected as other control room equipment and cable runs therein. Nonsafety-related computers outside the control room complex should be separated from safety-related areas by fire barriers with a minimum rating of 3 hours and should be protected as needed to prevent fire and smoke damage to safety-related equipment.

e. Switchgear Rooms

Switchgear rooms containing safety-related equipment should be separated from the remainder of the plant by barriers with a minimum fire rating of 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 combustible loading. These rooms should not be used for any other purpose. Fire hose stations and portable fire extinguishers should be readily available outside the area.

Equipment should be located to facilitate access for manual firefighting. Drains should be provided to prevent water accumulation from damaging safety-related equipment (see NFPA 92M, "Waterproofing and Draining of Floors"). Remote manually actuated ventilation should be provided for venting smoke when manual fire suppression effort is needed (see Position C.5.f).

f. Remote Safety-Related Panels

Redundant safety-related panels remote from the control room complex should be separated from each other by barriers having a minimum fire rating of 3 hours. 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 safety-related panels should be provided with automatic fire detectors that alarm locally and alarm and annunciate in the control room. Combustible materials should be controlled and limited to those required for operation. Portable extinguishers and manual hose stations should be readily available in the general area.

g. Safety-Related Battery Rooms

Safety-related battery rooms should be protected against fires and explosions. Battery rooms should be separated from each other and other areas of the plant by barriers having a minimum fire rating of 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 vol-%. Loss of ventilation should be alarmed in the control room. Standpipe and hose and portable extinguishers should be readily available outside the room.

h. Turbine Building

The turbine building should be separated from adjacent structures containing safety-related equipment by a fire barrier with a minimum rating of 3 hours. The fire barriers should be designed so as 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.

i. Diesel Generator Areas

Diesel generators should be separated from each other and from other areas of the plant by fire barriers having a minimum fire resistance rating of 3 hours.

Automatic fire suppression should be installed to combat any diesel generator or lubricating oil fires; such systems should be designed for operation when the diesel is running without affecting the diesel. Automatic fire detection should be provided to alarm and annunciate in the control room and alarm locally. Hose stations and portable extinguishers should be readily available outside the area. Drainage for firefighting water and means for local manual venting of smoke should be provided.

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

(1) The day tank is located in a separate enclosure with a minimum fire resistance rating of 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

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

j. Diesel Fuel Oil Storage Areas

Diesel fuel oil tanks with a capacity greater than 1,100 gallons should not be located inside buildings containing safety-related equipment. If above-ground tanks are used, they should be located at least 50 feet from any building containing safety-related equipment or, if located within 50 feet, they should be housed in a separate building with construction having a minimum fire resistance rating of 3 hours. Potential oil spills should be confined or directed away from buildings containing safety-related equipment. Totally buried tanks are acceptable outside or under buildings (see NFPA 30, "Flammable and Combustible Liquids Code," for additional guidance).

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

k. Safety-Related Pumps

Pump houses and rooms housing redundant safety-related pump trains should be separated from each other and from other areas of the plant by fire barriers having at least 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 safety-related equipment required for safe plant shutdown. Fire detection should alarm and annunciate in the control room and alarm locally. Hose stations and portable extinguishers should be readily accessible.

Floor drains should be provided to prevent water accumulation from damaging safety-related equipment (see Position C.5.a.(14)).

Provisions should be made for manual control of the ventilation system to facilitate smoke removal if required for manual firefighting operation (see Position C.5.f).

l. New Fuel Area

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

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

m. Spent Fuel Pool Area

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

n. Radwaste and Decontamination Areas

Fire barriers, automatic fire suppression and detection, and ventilation controls should be provided.

o. Safety-Related Water Tanks

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

p. Records Storage Areas

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

q. Cooling Towers

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

r. Miscellaneous Areas

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

8. Special Protection Guidelines

a. Storage of Acetylene-Oxygen Fuel Gases

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

b. Storage Areas for Ion Exchange Resins

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

c. Hazardous Chemicals

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

d. Materials Containing Radioactivity

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

REFERENCES

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NFPA 4A-1969, "Fire Department Organization."

NFPA 6-1974, "Industrial Fire Loss Prevention."

NFPA 7-1974, "Fire Emergencies Management."

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

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

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NFPA 12A-1973, "Halon 1301 Systems."

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NFPA 27-1975, "Private Fire Brigade."

NFPA 30-1973, "Flammable Combustible Liquids Code."

NFPA 51B-1976 "Cutting and Welding Processes."

NFPA 69-1973, "Explosion Prevention Systems."

NFPA 70-1975, "National Electrical Code."

NFPA 72D-1975, "Proprietary Protective Signaling Systems."

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NFPA 80-1975, "Fire Doors and Windows."

NFPA 92M-1972, "Waterproofing and Draining of Floors."

NFPA 197-1966, "Initial Fire Attack, Training, Standard On."

NFPA 204-1968, "Smoke and Heat Venting Guide."

NFPA 220-1975, "Types of Building Construction."

NFPA 251-1975, "Fire Tests, Building Construction and Materials."

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NFPA 802-1974, "Recommended Fire Protection Practice for Nuclear Reactors."

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Section 9.5.1, "Fire Protection Program."

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

Section 6.4, "Habitability Systems."

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

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

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

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

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

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

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

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

Other Documents

ANSI Standard B31.1-1973, "Power Piping."

ASTM D-3286, "Test for Gross Calorific Value of Solid Fuel by the Isothermal-Jacket Bomb Calorimeter (1973)."

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APPENDIX A TO BRANCH TECHNICAL POSITION APCSB 9.5-1
"GUIDELINES FOR FIRE PROTECTION FOR NUCLEAR POWER PLANTS
DOCKETED PRIOR TO JULY 1, 1976" (August 23, 1976)

(The guidelines of this appendix have been incorporated into BTP CMEB 9.5-1 and therefore this appendix has been deleted.)