

Clarification of NRC Regulatory Expectations Regarding Fire-Induced Circuit Failures

PURPOSE:

The staff is clarifying regulatory expectations regarding the protection of post-fire safe shutdown capability against fire-induced circuit failures, including multiple spurious actuations. This clarification applies existing regulatory positions from Generic Letter 81-12, "Fire Protection Rule," Generic Letter 86-10, "Implementation of Fire Protection Requirements," and Regulatory Issue Summary 2006-10, "Regulatory Expectations with [10 CFR 50] Appendix R Paragraph III.G.2 Operator Manual Actions," to the resolution of the fire-induced circuit fault issue. This clarification intends to provide a technically sound and traceable regulatory framework and provide permanent closure to this issue.

BACKGROUND:

Beginning in 1997, the staff noticed that a series of licensee event reports (LERs) identified plant-specific problems related to potential fire-induced electrical circuit faults that could disrupt operation of equipment necessary to achieve and maintain safe shutdown. In 1998, the staff began interaction with stakeholders to understand the problem and develop an effective solution to the circuit analysis issue. The staff issued Information Notice (IN) 99-17, "Problems Associated with Post-Fire Safe-Shutdown Circuit Analyses," on June 3, 1999, to document additional problems.

In 2001, the Electric Power Research Institute (EPRI) and Nuclear Energy Institute (NEI) performed a series of cable functionality fire tests to further the nuclear industry's understanding of fire-induced circuit failures, particularly spurious equipment actuations initiated by circuit faults. EPRI coordinated this effort and issued the final report, EPRI Report No. 1006961, "Spurious Activation of Electrical Circuits Due To Cable Fires." Additional analysis of the EPRI/NEI test results can be found in NUREG/CR-6776, "Cable Insulation Resistance Measurements Made During Cable Fire Tests." The NRC conducted additional testing and following response to public comments on the draft test report, published Cable Response to Live Fire (CAROLFIRE) report in April 2008 to further enhance knowledge of fire-induced circuit failures. CAROLFIRE is documented in NUREG/CR-6931, "CAROLFIRE Test Report." Based on the EPRI and NRC test results, circuit failures may occur in rapid succession (without adequate time to resolve one before a second circuit failure occurs). This testing-based conclusion caused the staff to question the industry position that circuit faults may be managed in a one-at-a-time approach. Based on the test results and interactions with industry, staff concluded that clarification of regulatory expectations was needed in the area of fire-induced circuit failures. This is particularly true with respect to crediting the mitigation of such faults in the post-fire safe-shutdown circuit analysis.

DISCUSSION:

NRC Staff Clarification of Fire-Induced Circuit Fault Requirements

The fundamental requirement in 10 CFR Part 50, Appendix R, Section III.G (Section III.G), is that fire protection be provided to insure post-fire safe shutdown capability. Specifically, the rule states, "Fire protection features shall be provided for structures, systems, and components important to safe shutdown." Lack of adequate assurance of the ability to safely shutdown due to a fire would constitute a violation of regulatory requirements.

To clarify requirements, the equipment important to safe shutdown in the plant during a fire will be divided into two classifications. The first is described in Section III.G.1.a as one train of systems necessary to achieve and maintain hot shutdown conditions (see Table 1, left column). This equipment is a subset of the more general set of equipment described in Section III.G.1 as structures, systems and components important to safe shutdown (see Table 1, right column.) As described below, the level of protection for each of these classifications of equipment is different.

For one train of systems necessary to achieve and maintain hot shutdown conditions as described in Section III.G.1.a (see Table 1, left column) protection is required to meet Section III.G.2, "Fire protection of safe shutdown capability," for plants licensed to operate prior to January 1, 1979 (pre '79 plants). For this equipment (left column of Table 1), there is no allowance for manual actions, or methods other than various combinations of (1) physical separation (e.g., rated fire barriers or separation with no intervening combustibles), (2) fire detection, and/or (3) fire suppression as described in Section III.G, to protect the train of systems necessary to achieve and maintain hot shutdown conditions. The left column of Table 1 provides details regarding the requirement to protect one train of systems necessary to achieve and maintain hot shutdown conditions.

Section III.G.1 requires that fire protection features be provided for the broader category of structures, systems and components, including circuits important to safe shutdown (right column of Table 1). However, for protection of this capability to safely shutdown, the same prescriptive requirements as listed in Section III.G.1.a and III.G.2 do not apply. The right column of Table 1 provides details regarding the protection of safe shutdown capability. For example, based on previous NRC guidance, manual actions or other methods may be used to demonstrate safe shutdown capability. Regulatory Issue Summary (RIS) 2006-10, "Regulatory Expectations with Appendix R Paragraph III.G.2, Operator Manual Actions," provides a discussion of protecting other safe shutdown equipment using methods such as manual actions, where one train of systems necessary to achieve and maintain hot shutdown conditions is protected in accordance with Section III.G.2 methods.

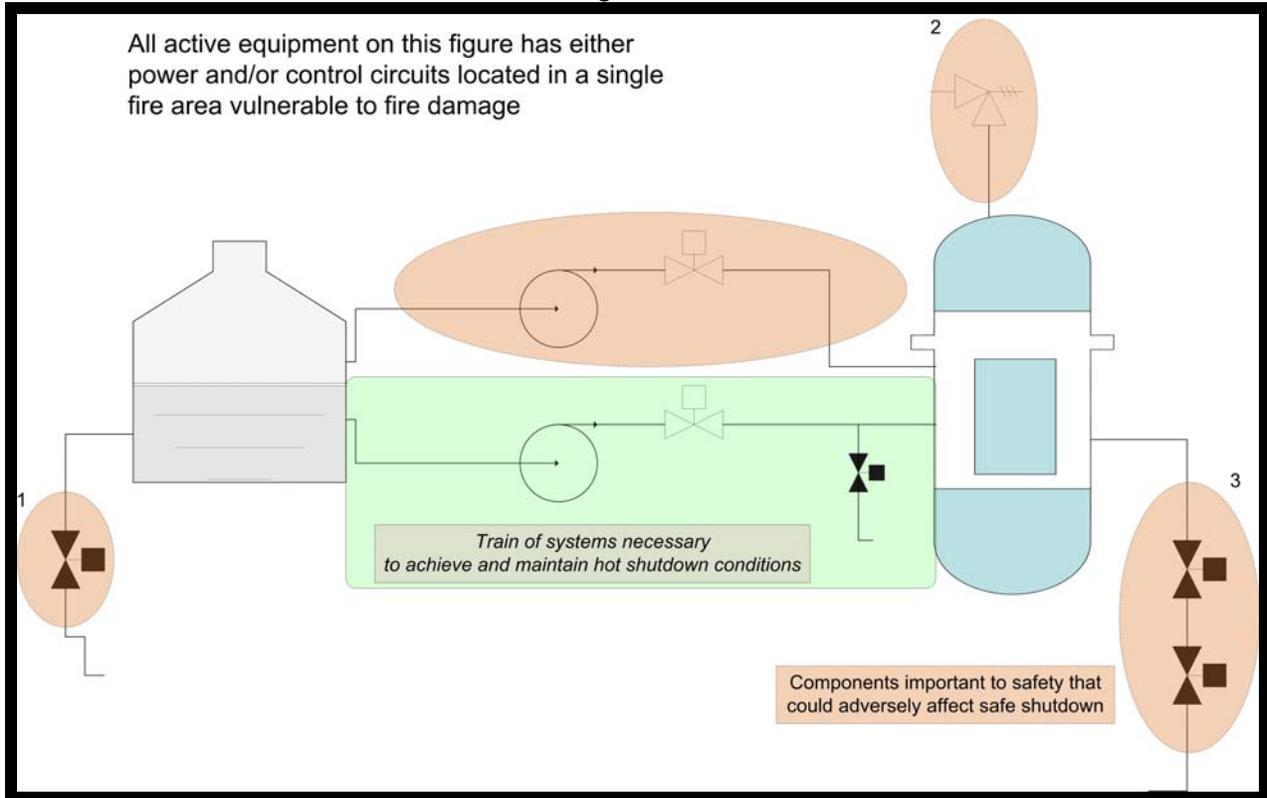
Figure 1 provides a generic graphical representation of equipment that is typically included in the train of systems necessary to achieve and maintain hot shutdown condition (in green box). The figure also shows equipment that is typically considered components important to safe shutdown that could adversely affect safe shutdown capability, that is could prevent shutdown or cause maloperation of safe shutdown systems (in orange ovals).

| Table 1 | | |
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| 10 CFR 50. Appendix R, III.G. " Fire protection of safe shutdown capability. 1. Fire protection features shall be provided for structures, systems, and components important to safe shutdown." | | |
| Rule Application | Requirement to protect "one train of systems necessary to achieve and maintain hot shutdown conditions" | "Fire protection features shall be provided for structures, systems and components important to safe shutdown." |
| Compliance Options | <p>III.G.1.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"</p> <p>III.G.2 ". . . ensuring that one of the redundant trains is free of fire damage. . ." a. . . . fire barrier having a 3-hour rating. . . b. . . . 20 feet with no intervening combustible or fire hazards. . . fire detectors and an automatic fire suppression system . . . ; or c. . . . a fire barrier having a 1-hour rating, . . . fire detectors and an automatic fire suppression system. . ."</p> <p>III.G.3 "Alternative or dedicated shutdown capability and its associated circuits, independent of cables, systems or components in the area, room, zone under consideration . . ."</p> | <p>Currently Developed Options: III.G.2 protection, and manual actions</p> <p>Options Under Development: Fire modeling, and NEI method in NEI 00-01</p> |

Table 1

| | | |
|--------------------|---|---|
| Discussion | <p>Circuits for trains of plant equipment that are required to operate for post-fire safe shutdown and equipment that assures availability of the train's required flow path must be protected so as to be free from fire damage, in accordance with III.G.1, 2 or 3.</p> <p>A train free of fire damage is demonstrated by rigorous design review and physical protection such as III.G.2. This includes consideration of single and multiple spurious actuations that could adversely affect the train of safe shutdown equipment. Manual actions, fire modeling, and risk-informed approaches such as the NEI method, cannot be used to demonstrate compliance without NRC approval.</p> | <p>Equipment that is not part of the train necessary to achieve and maintain hot shutdown conditions or is not necessary to assure availability of the hot shutdown train's flow path, but could otherwise prevent safe shutdown must be protected against fires that affect the safe shutdown systems capability. This includes multiple spurious actuation of such equipment.</p> <p>Manual actions and fire modeling are approaches that can be used to demonstrate compliance without NRC approval.</p> |
| Equipment Examples | <p>Coolant source, motive power, and flow path required to assure reactivity control, inventory control, and heat removal. Specific examples would be pumps, flow path valves, and necessary instrumentation.</p> | <p>RHR/RCS isolation valves, ADS valves, steam generator atmospheric dump vales, and steam bypass valves, when this equipment is not part of train of systems required for safe shutdown</p> |

Figure 1



Options to Protect One Train of Systems Necessary to Achieve and Maintain Hot Shutdown Conditions (Left Column of Table 1 and Green Box in Figure 1)

The train of systems necessary to achieve and maintain hot shutdown must be protected in a prescriptive manner consistent with 10 CFR Part 50, Appendix R Section III.G.2, including those areas where redundant trains are located in the same fire area. This includes source, motive power, and flow path required to assure reactivity control, make-up, cooling and necessary instrumentation, such as pumps and flow path valves indication. Required protection includes multiple spurious actuations that could adversely affect the train of systems necessary to achieve and maintain hot shutdown conditions.

Options to Protect Components Important to Safe Shutdown That Could Adversely Affect Safe Shutdown Capability (Right Column of Table 1 and Orange Ovals in Figure 1)

The protection options available as part of 10 CFR Part 50, Appendix R Section III.G.2 are also available but not required for the protection of the components important to safe shutdown. In addition, the use of operator manual actions is well established to provide for the capability to safely shutdown in the event of fire damage to circuits important to safe shutdown capability that are not part of the train required to achieve and maintain hot shutdown. In addition to the use of manual actions, the staff plans to work with the industry to provide regulatory guidance documents for additional methods for circuit analysis and protection.

Application to 10 CFR Part 50, Appendix R Section III.G.3 for Rooms Such As the Control Room and Cable Spreading Rooms

This clarification also applies to plant control rooms, cable spreading rooms and other 10 CFR Part 50, Appendix R Section III.G.3, alternate or dedicated shutdown areas. The implementation for these areas differs due to the fact that the NRC provided Safety Evaluation Reports to licensees for their alternate and dedicated shutdown strategies at the time that 10 CFR Part 50, Appendix R, Section III.G, was being implemented at each plant. These Safety Evaluation Reports are referenced in each plant's fire protection license condition.

In addition, consistent with Generic Letter 86-10, Question 5.3.10, licensees need only to consider one spurious actuation or signal until control of the plant is achieved from the alternate or dedicated shutdown system. Following control of the plant from the alternative or dedicated shutdown system, single or multiple spurious actuations that could occur in the fire affected area must be considered in accordance with the plant's approved fire protection program. The approved shutdown strategies vary from plant to plant.

Regulatory Implications for Plants Licensed After January 1, 1979

This approach also applies to plants that were licensed after January 1, 1979, that are not specifically required to meet the requirements of 10 CFR Part 50, Appendix R, Section III.G. These plants have an approved fire protection program based on a review against the guidance in NUREG-0800, "Standard Review Plan" (SRP), Section 9.5.1, "Fire Protection." The SRP, Section 9.5.1, includes similar wording as is included in 10 CFR Part 50, Appendix R, Section III.G. An NRC Safety Evaluation Report was issued documenting the NRC review of the facilities fire protection program. In addition, licensees have a license condition that says licensees may make changes to the approved fire protection program without prior approval of

the Commission only if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire. The staff considers changes that would permit the use of manual actions or other analysis methods in lieu of the prescriptive protection for the train of systems necessary to achieve and maintain hot shutdown conditions (left column) as an adverse affect on the ability to achieve and maintain safe shutdown capability. Such a change would therefore require prior NRC approval.

The staff is aware of two facilities licensed after 1979 for which the above information would not apply. These facilities have NRC Safety Evaluation Reports documenting approval of a fire protection program specifically protecting against only one spurious actuation. If, in the course of the NRC inspection process, risk-significant multiple spurious actuations are identified at these facilities the staff will consider the need for revision of that plant's licensing basis under the NRC's plant specific backfit provisions and 10 CFR 50.109, "Backfitting." The inspection process currently specifically looks for risk-significant multiple spurious actuations, therefore no change to the inspection process is required.

Treatment of Circuit Failures for New Reactor Plants

The fire protection programs for new reactor plants are subject to 10 CFR 50.48(a) and the Commission-approved criteria for enhanced fire protection.¹ The enhanced fire protection criteria ensures that safe shutdown can be achieved by assuming that all equipment in any one fire area will be rendered inoperable by fire for all areas of the plant.² As a result, the potential for fire induced circuit failures and multiple spurious actuations to adversely affect the ability to shutdown is greatly reduced. Consequently, licensees of new reactor plants have more flexibility than existing plants in their approach to addressing any potential multiple spurious actuations that could occur.

New reactor plants will have an approved fire protection program based on a review in accordance with NUREG-0800, "Standard Review Plan" (SRP), Section 9.5.1, "Fire Protection." License applicants must demonstrate that they have systematically identified possible multiple spurious actuation scenarios that could prevent safe shutdown and must describe their approach to addressing each scenario such that post-fire safe shutdown is ensured. The staff's approach for crediting of operator manual actions, fire modeling, etc., to ensure safe shutdown will be consistent with the guidance for these methodologies as are proposed for existing reactors.

¹ SECY-90-016, "Evolutionary Light-Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements;" SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs " and SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs."

² The control room is excluded from this approach, provided an independent alternative shutdown capability is included in the design. For the reactor containment building fire protection for redundant shutdown systems will ensure, to the extent practicable, that one shutdown division will be free of fire damage.