ENCLOSURE 1

GUIDANCE FOR POST FIRE SAFE SHUTDOWN CIRCUIT ANALYSIS

NEI 00-01 [Revision 2c]

GUIDANCE FOR POST FIRE SAFE SHUTDOWN CIRCUIT ANALYSIS

December 2008

Nuclear Energy Institute, 1776 I Street N. W., Suite 400, Washington D.C. (202.739.8000)

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NEI also extends its thanks to the following organizations playing important roles in the completion of this guidance:

- EPRI: Funded a significant series of circuit failure tests and the Expert Panel who developed spurious actuation probabilities from the test results
- BWR Owners Group: Developed the deterministic portion of the NEI 00-01 guidance
- Westinghouse/CE and B&W Owners Groups: Along with the BWROG, funded the pilot applications of NEI 00-01 and a significant portion of the report preparation
- Duke Energy and NMC Corporation: Hosted pilot applications of NEI 00-01
- Omega Point Laboratories: Provided a cost-effective test facility for circuit failure testing
- The NRC and Sandia National Laboratories: Provided extensive participation in the EPRI/NEI circuit failure testing, and review and comment on NEI 00-01
- Edan Engineering: Wrote the EPRI report on the circuit failure testing and the analysis in Appendix B.1 on Multiple High Impedance Faults.

EXECUTIVE SUMMARY

NEI 00-01 was developed to provide a deterministic methodology for performing post-fire safe shutdown analysis. In addition, NEI 00-01 includes information on risk-informed methods (when allowed within a Plant's License Basis) that may be used in conjunction with the deterministic methods for resolving circuit failure issues related to Multiple Spurious Operations (MSOs). The risk-informed method is intended for application by utilities to determine the risk significance of identified circuit failure issues related to MSOs. The deterministic safe shutdown analysis method described in Revision 0 of this document reflected practices in place for many years at a wide cross-section of U.S. nuclear plants and widely accepted by NRC. These practices were generally reflected in the plant's licensing basis. In Revision 1, these deterministic methods were revised to address insights gained from EPRI/NEI circuit failure testing and reflected in NRC's RIS 2004-03. While these insights do not change a plant's licensing basis, they reflect the NRC's new emphasis on considering potential safety implications of MSOs. This emphasis on MSOs became apparent as the NRC revised their inspection guidance to resume the inspection of circuits in January 2005. The methods presented in Revision 1 were intended to support licensees preparing for the resumed NRC circuit failure inspections.

In Revision 2 changes were made to document the Resolution Methodology presented by the Industry to the NRC Staff for resolving the MSO Issue subsequent to the rejection of the Staff's generic letter on MSOs by the Commission. The methodology in Revision 2 reflects insights gained from, not only the EPRI/NEI Cable Fire Testing, but also the CAROLFIRE Cable Fire Testing, the outcome of meetings with the NRC Staff and information provided within SECY 08-0093 and a draft revision to Reg Guide 1.185189. These changes were made to address NRC comments related to segregating those components necessary for post-fire hot safe shutdown ("green box", defined in 10CFR50, Appendix R, Section III.G.1.a as one train of systems necessary to achieve and maintain hot shutdown conditions) and those whose mal-operation could provide a potential impact to post-fire safe shutdown ("orange box", defined 10CFR50, Appendix R, Section III.G.1 as components important to safe-shutdown that could adversely affect safe shutdown capability or cause mal-operation of safe shutdown systems~~).~~).). The methodology contained in Revision 2 is one method of addressing post-fire safe shutdown and the MSO Issue.

Comment [h1]: 1.189

This document neither changes nor supports any individual plant's licensing basis. The assumptions used in the licensing basis and the nature of any approvals the NRC may have provided for these assumptions, are a plant-specific matter between each licensee and the NRC.

NEI 00-01 Revision 2, Chapter 5, provides a methodology for a focused-scope Fire PRA for assessing the risk significance of specific MSOs. This method is intended for application to circuit failures involving MSOs. All MSO impacts deemed to be risk significant should be placed in the plant Corrective Action Program with an appropriate priority for action. Since a large number of low significance findings of uncertain compliance status could result from industry applications of this method to MSOs, separate discussions are being held with NRC to address the handling of such issues without unnecessary resource impacts for licensees and NRC alike.

It is expected that plants adopting a new fire protection licensing basis using NFPA 805 will be able to reference certain sections of NEI 00-01 as an acceptable method for addressing circuit failure issues, including the MSO Issue. It is noted that plants adopting the NFPA 805 licensing basis in accordance with NEI 04-02, Revision 1 utilized NEI 00-01 Revision 1 as part of the review and confirmation process of the nuclear safety methodology review. NEI 00-01 Revision 1 Chapter 3 serves as the basis for nuclear safety methodology reviews performed in accordance with NEI 04-02, Revision 1, Regulatory Guide 1.205, Revision 0, as supplemented by NFPA 805 Frequently Asked Question 07-0039, Revision 2 (ADAMS Accession No. ML082590466).

Comment [h2]: Technical agreement on this FAQ has been reached but the closure memo has yet to be issued.

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ATTACHMENTS

APPENDICES

FIGURES

TABLES

ATTACHMENTS

Comment [RFR3]: Attachments are listed twice.

GUIDANCE FOR POST-FIRE SAFE SHUTDOWN CIRCUIT ANALYSIS

1 INTRODUCTION

For some time there has been a need for a comprehensive industry guidance document for the performance of post-fire safe shutdown analysis to implement existing fire protection regulations. Such a document is needed to consistently apply the regulatory requirements for post-fire safe shutdown analysis contained in 10 CFR 50.48 (Reference 67.4.1) and 10 CFR 50 Appendix R (Reference 67.4.3).

From the standpoint of deterministic safe shutdown analysis, Generic Letter 86-10 (Reference 76.1.10) provided standardized answers to certain questions related to specific issues related to this topic. The answers provided, however, did not comprehensively address the entire subject matter. The lack of comprehensive guidance for post-fire safe shutdown analysis, in combination with the numerous variations in the approach used by the architect engineers responsible for each plant design, have resulted in wide variation in plant-specific approaches to deterministic post-fire safe shutdown analysis.

Some of these approaches are based on long-held industry interpretations of the NRC regulations and guidance. In many cases, these interpretations were not documented in a manner that indicated a clear NRC acceptance of the position. In an NRC letter to NEI in early March 1997 (Reference 67.4.30) NRC stated that the regulatory requirements and staff positions are well documented, and that regulatory requirements recognize that fires can induce multiple hot shorts. The industry responded (Reference 67.4.31) that industry and NRC staff interpretations of existing regulations and regulatory guidance differ significantly on at least some aspects of the post-fire safe shutdown analysis requirements and provided reasons for these differing interpretations. The Boiling Water Reactor Owners Group (BWROG) developed a comprehensive document for BWRs to compile deterministic safe shutdown analysis practices based on existing regulatory requirements and guidance. That document was adopted into NEI 00-01 with minor changes to address PWR-specific safe shutdown analysis considerations.

1.1 PURPOSE

The purpose of this document is to provide a consistent process for performing a post-fire safe shutdown circuit analysis. While it describes differences between NRC and industry licensing positions, NEI 00-01 does not define what any plant's licensing basis is or should be. Plant licensing bases have been developed over many years of licensee interactions with NRC staff, and the interpretation of these licensing bases is a matter between each licensee and NRC staff. The guidance provided in this document accounts for differences and uncertainties in licensing basis assumptions about circuit failures. It also provides a method for the resolution of the differences between the NRC and the industry related to fire-induced circuit failures resulting in MSOs.

This document provides deterministic methods for addressing potential fire-induced circuit failure issues, either within or beyond the existing plant's licensing basis. The deterministic method, derived from NRC regulations, guidance, and plant licensing bases is provided for analyzing and resolving circuit failure issues. Methods are provided to (1) select circuits and appropriate combinations thereof for the analysis of MSOs (note: the terms spurious actuation and spurious operation are considered synonymous. The term "spurious operation" is used in this document for consistency), and (2) determine the risk significance of identified circuit failure combinations (MSOs). While the selection of circuit failure combinations, MSOs, has not traditionally been included in plant circuit analysis methods to date, it is appropriate to consider such combinations in the light of the results of recent cable failure testing, both EPRI/NEI and CAROLFIRE. The Resolution Methodology for MSOs included in this document will assist the licensee in determining whether potentially risk-significant interactions could impact safe shutdown, but this Resolution Methodology does not change the plant licensing basis.

The methods in this document do not require the systematic re-evaluation of a plant's post-fire safe shutdown circuit analysis. Such a systematic re-evaluation is entirely a licensee decision that may be based on NRC inspection findings, licensee self-assessment results, or industry experience. Neither do these methods take precedence over specific requirements accepted by the NRC in a plant's post-fire safe shutdown analysis. The deterministic methods in this document rely on approved licensing bases for individual plants. In addition, this document provides criteria for assessing the risk significance of those MSO issues that may not be included in current safe shutdown analyses, but that may be a concern because of potential risk significance.

The guidance in this document reflects the position that licensees should address potential risk-significant issues regardless of whether they involve compliance with the licensing basis. When issues are identified, the licensee should consider whether they involve violations of the licensing basis, are beyond the licensing basis, or are of uncertain compliance status and subject to possible disagreement with NRC. Licensees should also consider the risk significance of the findings consistent with the fire protection SDP. Consideration of these parameters is illustrated in the following table:

Type of Issue	Action to Address Issue: Issue Risk Significant	Action to Address Issue: Issue Not Risk Significant
Finding (issue outside CLB)	Address in CAP	Green finding; action at licensee's discretion
Violation of CLB	Address in CAP	Address in CAP or provide licensing basis changes (using approved regulatory processes)
Compliance status/ CLB not clear	Address in CAP	Address in CAP or provide licensing basis changes (using approved regulatory processes)

Comment [RFR4]: First time used – spell out.

Comment [RFR7]: Spell out-first time

Comment [h5]: Needs an explanation. Licensees will claim that they don't have to address MSOs.

Comment [RFR6]: Spell out-first time

Comment [h8]: Green findings require resolution. To be revise to be like the other two choices for Issue Not Risk Significant.

As seen in the table above, NEI 00-01 concludes that the licensees should address risk-significant circuit failure issues regardless of whether they involve potential violations. Issues that are both risk-insignificant and outside the licensing basis should be treated in accordance with current ROP guidelines as illustrated in the table. Remaining low significance issues potentially involving compliance should be addressed consistent with current regulatory guidelines; licensing basis changes (using approved regulatory processes) may be in order, supported by the risk analysis performed using Section 5 risk analysis or the fire protection SDP methods.

An example will illustrate the use of NEI 00-01. In this example, assume that the licensee conducts a self-evaluation using this document and determines that he should postulate more than one simultaneous spurious operation in a certain fire area. Further assume that the licensing basis is inconclusive. The licensee could determine the risk significance of the issue using the methods of NEI 00-01, the revised fire protection Significance Determination Process, or other plant-specific risk analyses. The licensee should place the issue in the plant Corrective Action Program (CAP) if it is significant according to the risk criteria used, or could request licensing basis changes (using approved regulatory processes), or change the fire protection plan, if it is not. The compliance aspects would also be addressed in cases where it is not clear whether an issue is within the licensing basis (a "compliance issue") or not.

Potentially, a large number of exemption requests (on an industry-wide basis) for low significance issues could result in an unnecessary expenditure of industry and staff resources. NRC and industry are discussing ways for addressing low significance issues with uncertain compliance status to minimize this resource expenditure while and still ~~address~~addressaddressing regulatory requirements. and ensuring plant safety.

Comment [e9]: There have not been a large number of exemptions related to manual actions. MSOs should be the same. Consider revising this paragraph.

1.2 BACKGROUND

Reviewing past fire events can substantiate the uncertainty associated with the behavior of actual plant fires. On March 22, 1975, the Browns Ferry Nuclear Power Plant had the worst fire ever to occur in a commercial nuclear power plant operating in the United States. (Reference U.S. Nuclear Regulatory Commission (NRC) Inspection and Enforcement (IE) Bulletin Nos. 50-259/75 and 50-260/75-1, dated 2/25/75.) The Special Review Group that investigated the Browns Ferry fire made two recommendations pertaining to assuring that the effectiveness of the fire protection programs at operating nuclear power plants conform to General Design Criterion (GDC) 3.

- The NRC should develop specific guidance for implementing GDC 3.
- The NRC should review the fire protection program at each operating plant, comparing the program to the specific guidance developed for implementing GDC 3.

In response to the first recommendation, the NRC staff developed Branch Technical Position (BTP) Auxiliary Power Conversion Systems Branch (APCSB) 9.5-1, "Guidance for Fire Protection for Nuclear Power Plants," May 1, 1976; and Appendix A to BTP APCSB 9.5-1, "Guidelines for Fire Protection for Nuclear Power Plants Docketed Prior to July 1, 1976," August 23, 1976. The guidance in these documents focused on the elements of fire protection defense-in-depth (DID): (1) prevention; (2) mitigation through the use of detection and suppression (automatic and manual); (3) passive protection of structures, systems and components (SSCs) important to safety and post-fire safe shutdown.

In response to the second recommendation, each operating plant compared its fire protection program with the guidelines of either BTP APCSB 9.5-1 or Appendix A to BTP APCSB 9.5-1. The staff reviewed the fire protection programs for compliance with the guidance.

The guidance in BTP APCSB 9.5-1 and Appendix A to BTP APCSB 9.5-1, however, did not provide sufficiently specific guidance for performing post-fire safe shutdown analysis. Also, independent testing sponsored by the NRC indicated that some of the separation concepts proposed by licensees under the BTP, such as coating intervening cable trays with fire retardant coatings, would not provide sufficient protection in the event of a severe fire. Thirdly, some licensees did not implement aspects of the BTP that the NRC Staff considered essential in order to achieve adequate protection. To address these issue and to provide the necessary guidance, the NRC issued 10 CFR 50.48, "Fire Protection," and Appendix R, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979," to 10 CFR Part 50 (45 FR 36082). The NRC published in the Federal Register (45 FR 76602) the final fire protection rule (10 CFR 50.48) and Appendix R to 10 CFR Part 50 on November 19, 1980. The Appendix R Regulation required compliance with sections III.G, III.J, and III.O for all plants licensed to operate before January 1, 1979, and also required individual licensees to comply with other lettered sections, based on the status of their outstanding items under the BTP review, as reflected by NRC correspondence to the individual licensees. Section III.G.2 of Appendix R reflected the results of the NRC's independent cable tray fire testing program, overriding any previous approvals the NRC may have granted regarding the protection of cables with fire retardant coatings.

This regulation applies to plants licensed to operate prior to January 1, 1979. For plants licensed to operate after January 1, 1979, the NRC staff, in most cases, required compliance with Appendix A to BTP APCSB 9.5-1 and Sections III.G, J & O of Appendix R. For these licensees, the sections of Appendix R apply to the plant as a licensing commitment, rather than as a legal requirement imposed by the code of federal regulations. Some other licensees provided comparisons to the guidelines of Section 9.5-1, "Fire Protection Program," of NUREG-0800, "Standard Review Plan," which incorporated the guidance of Appendix A to BTP APCSB 9.5-1 and the criteria of Appendix R, or BTP CMEB 9.5-1. Additionally, some plants had aspects of their programs reviewed to the criteria contained in Draft Regulatory Guide 1.120 Revision 1 ("Fire Protection Guidelines for Nuclear Power Plants," November 1977), which primarily reflected the content of BTP APCSB 9.5-1 Revision 1. Therefore, even though fire protection programs can be essentially equivalent from plant to plant, the licensing basis upon which these programs are founded can be very different. Most plants licensed after January 1, 1979 have also been granted by the NRC a standard fire protection license condition allowing them to selfapprove and make changes to their NRC approved fire protection program provided such changes do not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire. Therefore, even for plants with a common regulatory basis traceable back to one of the regulations and or guidance listed above, the details of implementing the fire protection program can be different.

The plant design changes required for passive and active fire protection features and administrative controls required by the regulations discussed were fairly specific. These changes have been implemented throughout the industry. These changes have been effective in preventing a recurrence of a fire event of the severity experienced at Browns Ferry.

; have increased the likelihood that a fire will be detected rapidly and extinguished; and have reduced the potential consequences of a fire (see Appendix A for a brief history of the Browns Ferry fire and a description of the fire protection improvements for nuclear plants since the Browns Ferry fire).

To clarify the regulations, the NRC staff has issued numerous guidance documents in the form of Regulatory Guides, memorandums, Regulatory Issue Summaries, Generic Letters and Information Notices. These documents provide insights as to the NRC staff's interpretation of the regulations, their views on acceptable methods for complying with the regulations, and clarity of the requirements necessary in performing a post-fire safe shutdown analysis.

1.3 OVERVIEW OF POST FIRE SAFE SHUTDOWN ANALYSIS

A fire in an operating nuclear power plant is a potentially serious event. In general, the likelihood of a large fire with the potential to damage plant equipment important to safe shutdown is considered to be small. The expected fire would be contained in a single electrical panel or a localized portion of one room or area. Typical plant design segregates important cables and equipment from threats such as missiles, flooding, and significant fire sources. The expected plant response to this type of event would be to maintain continued operation and to dispatch the plant fire brigade to extinguish the fire.

Despite this, the consequences of an event that damages plant equipment important to safe shutdown can be significant. The Browns Ferry fire resulted in damage to plant equipment important to safe shutdown. Although safe shutdown of the Browns Ferry unit was ultimately accomplished, the event was of sufficient significance to warrant major changes in fire protection design features of a nuclear power plant. Appendix A to this document provides a description of the improvements made in the fire protection design of nuclear power plants in response to the Browns Ferry fire event.

In addition to plants making changes to the fire protection design features, they have also placed increased attention on identifying those systems and equipment important to the post-fire safe shutdown of each unit. A safe plant design is achieved by identifying the systems and equipment important to post-fire safe shutdown, in each area of the plant; making conservative assumptions regarding the extent of fire damage; and assuring adequate separation of the redundant safe shutdown trains. or protection of an alternative/dedicated shutdown train. When applied to the fire protection program of a nuclear power plant, tThese aspects of post-fire safe shutdown design, in combination with the other changes made in the design of ~~the~~the~~the~~to plant fire protection programsfeatures in response to the Browns Ferry fire, provide reasonable assurance that a plant fire will not prevent safe plant shutdownsolidify the conclusion that current design approaches used for addressing plant fires provide for a safe plant design.

The goal of post-fire safe shutdown is to assure that a single fire in any plant fire area will not result in any fuel cladding damage, rupture of the primary coolant boundary or rupture of the primary containment. This goal serves to prevent an unacceptable radiological release as a result of the fire. This goal is accomplished by assuring, in accordance with NRC regulatory requirements, the following deterministic criteria are satisfied for a single fire in any plant fire area:

- One safe shutdown path necessary to achieve and maintain hot safe shutdown is free of fire damage. The set of components necessary to achieve and maintain post-fire hot shutdown is referred to throughout this document as the "required for hot shutdown".
- Potential fire-related impacts to ~~component~~componentcomponents with the potential to mal-operate and adversely impact the ability of the safe shutdown pathcomponents described above to perform its post-fire safe shutdown functions are prevented or can behave been adequately mitigated. The set of components whose mal-operation could impact the components on the required safe shutdown path in a particular fire area are referred to throughout this document as "important to safe shutdown".
- Potential impacts of Systems, Structures and Components (SSCs) whose mal-operation or spurious operation could adversely impact the ability to achieve and maintain safe shutdown (previously referred to as Associated Circuits).
- Repairs to systems and equipment required to achieve and maintain cold shutdown can be accomplished within the required time frame.
- Any operator manual actions required to support achieving either hot or cold shutdown are identified and meet the applicable regulatory acceptance requirements.

The deterministic methods in Section 3 integrate the requirements and interpretations related to post-fire safe shutdown into a single location, and assure that these criteria are satisfied. These methods:

- Identify the structures, systems, equipment and cables required to support the operation of each safe shutdown pathtrain.
- Identify the equipment and cables whose spurious operation could adversely impact the ability of these safe shutdown paths to perform their required safe shutdown function.
- Provide techniques to mitigate the effects of fire damage to components on or affecting the required safe shutdown path in each fire area.

Using these methods to perform the post-fire safe shutdown analysis will meet deterministic regulatory requirements and provide an acceptable level of safety resulting in a safe plant design. It is consistent with the fire protection defense-in-depth concept that addresses uncertainties associated with the actual behavior of fires in a nuclear power plant. Post-fire safe shutdown is one part of each plant's overall defense-in-depth fire protection program. The extent to which the requirements and guidance are applicable to a specific plant depends upon the age of the plant and the commitments established by the licensee in developing its fire protection program.

Comment [RFR10]: While "hot shutdown" may be consistent with past NRC documents, "safe shutdown" is more inclusive – typical throughout. This document uses hot shutdown and safe shutdown interchangeably. "Hot" shutdown is appropriate when quoting rule language, but this document typically uses "safe" shutdown elsewhere.

Formatted: Bullets and Numbering

The information contained in Chapters 4 and 5 are provided for use in resolving the longstanding issues of MSOs. Using the Resolution Methodology described in these chapters and in the appendices referenced within Chapters 4 and 5 is one way for a licensee to address the MSO issue.

Comment [RFR11]: Prior to this, each part of the document has been referred to as a "Section". Use of Chapter versus Section is inconsistent throughout document.

1.3.1 GENERAL METHODOLOGY DESCRIPTION

The deterministic methodology described in this document can be used to perform a post-fire safe shutdown analysis to address the current regulatory requirements. The Resolution Methodology for MSOs evaluates the risk significance of potential failures or combinations of failures. [Note: The term "MSOs" will be used throughout this document to denote one or more fire-induced component failures due to fire-induced circuit failures, including, but not limited to spurious operations resulting from hot shorts.] The Resolution Methodology for addressing MSOs is contained in Chapter 4.

1.3.2 DETERMINISTIC METHOD

When using the deterministic methodology described in Chapter 3 of this document to address the current regulatory requirements, a basic assumption of the methodology is that there will be fire damage to systems and equipment located within a common fire area. The size and intensity of the fire required to cause this type of system and equipment damage is not determined. Rather, fire damage is assumed to occur regardless of the level of combustibles in the area, the ignition temperatures of any combustible materials, the lack of an ignition source or the presence of automatic or manual fire suppression and detection capability. Fire damage is also postulated for all cables and equipment in the fire area that may be used for safe shutdown, even though most plant fire areas do not contain sufficient fire hazards for this to occur.

It is with these basic and conservative assumptions regarding fire damage that use of the Chapter 3 methodology begins. The methodology progresses by providing guidance on selecting systems and equipment needed for post-fire safe shutdown, on identifying the circuits of concern relative to these systems and equipment and on mitigating each fire-induced effect to the systems, equipment and circuits for the required safe shutdown path in each fire area. This methodology represents a comprehensive and safe approach for assuring that an operating plant can be safely shut down in the event of a single fire in any plant fire area.

To address the MSO issue, consideration is given to the MSO List in Appendix G and the circuit failure criteria contained in Appendix B. The circuit failure criteria contained in Appendix B is intended for use with the MSO List in Appendix G and the MSO Resolution Methodology described in Chapter 4. It is not intended to supersede any of the circuit failure criteria contained in Chapter 3. Using the Resolution Methodology described in Chapter 4, a licensee can determine the potential fire-induced MSO impacts applicable to its facility. These potential fire-induced impacts can then be dispositioned using the deterministic methods described in Chapter 3 or by using the risk-informed method described in Chapter 5. Additionally, fire modeling, as described in Chapter 4, may be used to assess whether or not a particular MSO in a particular location presents an potential impact to post-fire safe shutdown. In addressing MSOs, the conservative assumptions discussed above for the Chapter 3 analysis are not necessarily applied, e.g. fire modeling or risk assessment may be an acceptable resolution approach. The mitigating techniques available for use with any particular MSO is a function of whether that MSO is classified as being comprised of required for hot shutdown components or important to safe shutdown components. Refer to Appendix H for a description of the criteria to be used to classify components as either required for hot shutdown or important to safe shutdown components. Additionally, the MSO's listed in Appendix G are to be evaluated separately. There is no need to evaluate for the combined aeffect~~affect~~ of multiple MSOs. The potential aeffect~~affect~~ of each MSO on post-fire safe shutdown is to be evaluated individually.

Comment [h12]: This is true if one fire cannot cause a combination of MSOs. If one fire can affect several different MSO combinations, they must be considered together.

Comment [RFR13]: What is the basis for this statement? How is this different from a one-at-a-time approach? Also I don't think you mean "multiple MSOs" or "each MSO" since MSO stands for multiple spurious operations.

Comment [e14]: How does one know that this is valid for a particular plant. Lets say PORV and Charging are both affected. I also know of some plants that have multiple components in one cable.

In performing a deterministic post-fire safe shutdown analysis, the analyst must be cautious not to improperly apply the conservative assumptions described above. For example, one cannot rule out fire damage to unprotected circuits in a given fire area. This assumption is conservative only in terms of not being able to credit the systems and equipment associated with these circuits in support of post-fire safe shutdown. If the analyst, however, were to assume that these circuits were to be damaged by the fire when this provided an analytical advantage, this would be non-conservative. For example, assuming that fire damage results in a loss of offsite power may be non-conservative in terms of heat loads assumptions used in an analysis to determine the need for room cooling systems for the 72-hour fire coping period.

The methodology for performing deterministic post-fire safe shutdown analysis is depicted in Figure 1-1. The specific steps are summarized in Sections 1.3.2.1 through 1.3.2.6, and discussed in depth in Section 3. The criteria for determining whether a component is a required for hot shutdown or important to safe shutdown component is contained in Appendix H.

1.3.2.1 Safe Shutdown Function Identification

The goal of post-fire safe shutdown is to assure that a single fire in any single plant fire area will not result in any fuel cladding damage, rupture of the primary coolant boundary or rupture of the primary containment. This goal is accomplished by determining those functions important to safely shutting down the reactor and assuring that systems with the capability to perform these functions are not adversely impacted by a single fire in any plant fire area. The safe shutdown functions important to the plant are: (1) reactivity control; (2) pressure control; (3) inventory control; and (4) decay heat removal. To accomplish the required safe shutdown functions, certain support system functions (e.g., electrical power, ventilation) and process monitoring capability (e.g., reactor level, pressure indication) are also required.

In addition, the analyst must assure that fire-induced spurious operations do not occur that can prevent equipment in the required safe shutdown path from performing its intended safe shutdown function. Examples of spurious operations that present a potential concern for the safe shutdown functions described above are those that can cause a: (1) loss of inventory in excess of the make up capability; (2) flow diversion or a flow blockage in the safe shutdown systems being used to accomplish the inventory control function; (3) flow diversion or a flow blockage in the safe shutdown systems being used to accomplish the decay heat removal function[1].

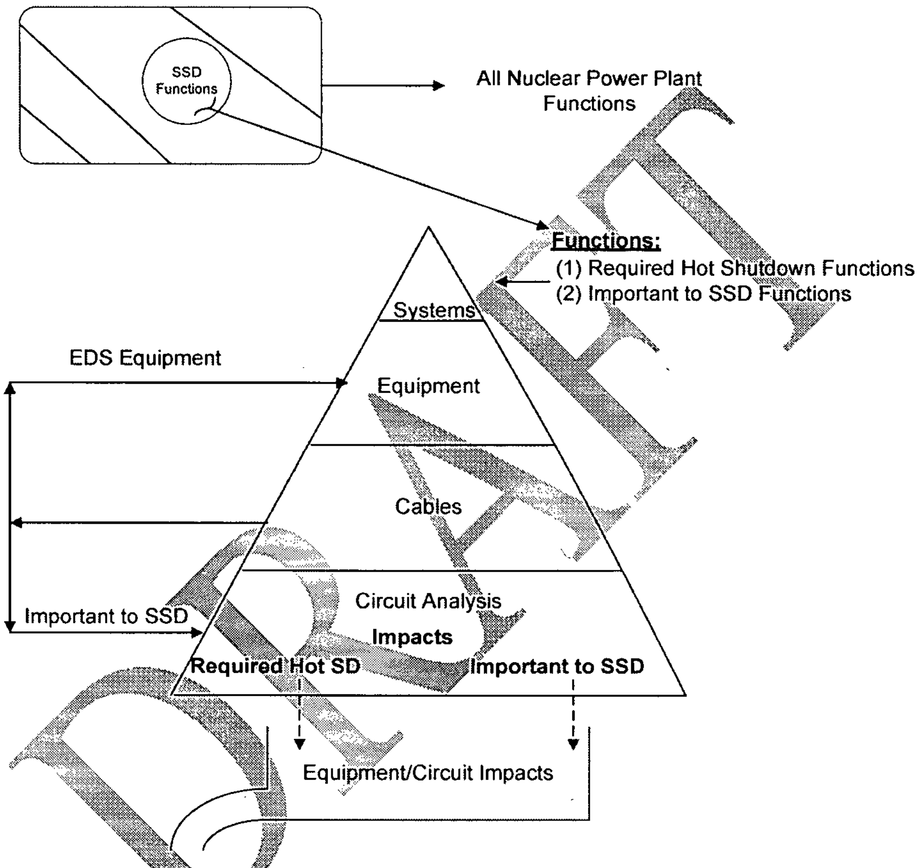
Comment [e15]: Flow diversion requires consideration also.

[BWR] Although an inadvertent reactor vessel overfill condition is not a safe shutdown function listed above, the NRC has identified this as a concern. The acceptability of the current design

[1] Licensing Citation: Brown's Ferry SER dated November 2, 1995 Section 3.7.3 third paragraph. Monticello Inspection report dated December 3, 1986 paragraph (2) page 16.

features of the BWR to mitigate the effects of an inadvertent reactor vessel overfill condition as a result of either a fire or equipment failure has been addressed by the BWROG in GE Report No. EDE 07—390 dated April 2, 1990, in response to NRC Generic Letter 89-19. The NRC subsequently accepted the BWROG position in a Safety Evaluation dated June 9, 1994. Despite this, some of the MSOs listed in Appendix G for BWRs relate to an inadvertent reactor vessel overfill. These will be addressed as a part of the MSO review.

Figure 1-1, Deterministic Post-Fire Safe Shutdown Overview



Mitigation Techniques

Required Hot Shutdown Components

Reroute, Re-analyze or Re-design Circuit

Protect in accordance with III.G.2

Other Plant Unique Approach:
- 86-10 Evaluation
- Exemption Request
- Deviation Request - LAR

Important to SSD Components

Any of the options available for Required Safe Shutdown Components

Operator Manual Action

For MSOs
- Fire Modeling
- Focused Scope Fire PRAs

1.3.2.2 Safe Shutdown System and Path Identification

Using the safe shutdown functions described above, the analyst identifies a system or combination of systems with the ability to perform each of these shutdown functions. The systems are combined to form safe shutdown paths.

1.3.2.3 Safe Shutdown Equipment Identification

Using the Piping and Instrument Diagrams (P&IDs) for the mechanical systems comprising each safe shutdown path, the analyst identifies the mechanical equipment required for the operation of the system and the equipment whose spurious operation could affect the performance of the safe shutdown systems. Equipment that is required for the operation of a safe shutdown system for a particular safe shutdown path is related to that path (and is designated as a required hot shutdown component).

From a review of the associated P&IDs, the equipment that could spuriously operate and result in a flow blockage, a flow diversion (e.g., inventory makeup capability), loss of pressure control (due to overfeeding, excessive steam leakage, etc.), etc. is identified. Similarly, this equipment is related to the particular safe shutdown path that it can affect. This equipment is designated as an important to safe shutdown component.

Comment [RFR16]: A flow blockage or flow diversion that could prevent safe shutdown should be designated as required for safe shutdown.

Using the criteria in Appendix H, the analyst classifies the components identified above either as required for hot shutdown component or as an important to SSD component.

The required safe shutdown path for any particular fire area is comprised of required and important to SSD components. The classification for a particular component in regards to being either a required or an important to SSD component can vary from fire area to fire area. Refer to Appendix H for additional details.

The analyst reviews the P&IDs for the systems physically connected to the reactor vessel to determine the equipment that can result in a loss of reactor inventory in excess of make up capability. This includes a special class of valves known as "high/low pressure interfaces." Refer to Appendix C for the special requirements associated with high/low pressure interface valves. Equipment in this category is typically related to all safe shutdown paths, since a loss of reactor vessel inventory would be a concern for any safe shutdown path.

1.3.2.4 Safe Shutdown Cable Identification

Using the electrical schematic drawings for the equipment identified above, the analyst identifies all the cables required for the proper operation of the safe shutdown equipment. This will include, in addition to the cables that are physically connected to the equipment, any cables interlocked to the primary electrical schematic through secondary schematics. The cables identified are related to the same safe shutdown path as the equipment they support.

While reviewing the electrical schematics for the equipment, the analyst identifies the safe shutdown equipment from the electrical distribution system (EDS). The EDS equipment (bus) for the safe shutdown path is associated with the equipment that it powers. All upstream busses are identified and similarly related to the safe shutdown path. In addition, all power cables associated with each bus in the EDS are identified and related to the same safe shutdown path as the EDS equipment. This information is required to support the Breaker Coordination Analysis.

1.3.2.5 Safe Shutdown Circuit Analysis

Using information on the physical routing of the required cables and the physical locations of all safe shutdown equipment, the analyst determines equipment and cable impacts for each safe shutdown path in each plant fire area. Based on the number and types of impacts to these paths, each fire area is assigned a required safe shutdown path(s). Initially, it is assumed that any cables related to a required safe shutdown component in a given fire area will cause the component to fail in the worst-case position (i.e. if the safe shutdown position of a valve is closed, the valve is assumed to open if the required cable is routed in the fire area).

If necessary, a detailed analysis of the cable for the specific effect of the fire on that safe shutdown path is performed. This is accomplished by reviewing each conductor in each of these cables for the effects of a hot short, a short-to-ground or an open circuit[2] (test results indicate that open circuits are not the initial fire-induced failure mode) and determining the impact on the required safe shutdown component. The impact is assessed in terms of the effect on the safe shutdown system, the safe shutdown path, the safe shutdown functions and the goal for post-fire safe shutdown.

For the Plant Specific List of MSOs developed using the Resolution Methodology outlined in Chapter 4, apply the Circuit Failure Criteria outlined in Appendix B as opposed to the circuit failure criteria discussed in the paragraph above.

Comment [h17]: Some aspects of the Appendix B circuit failure criteria are non-conservative and therefore not endorsed.

1.3.2.6 Safe Shutdown Equipment Impacts

Using the process described above, the analyst identifies the potential impacts to safe shutdown equipment, systems, paths, and functions relied upon in each fire area, and then ~~mitigate~~mitigatemitigates the effects on safe shutdown for each safe shutdown component impacted by the fire. The mitigating techniques must meet the regulations. For example, for required for hot shutdown components the mitigating techniques listed in Figure 1-1 for required hot shutdown components apply. For required for hot shutdown components, in addition to the available options of re-designing the systems and/or affected circuits and processing Exemption Requests ofrof or License Amendment Requests (LARs), the protection schemes of Appendix R Section III.G.2 are to be applied. If the component, however, is classified as an important to SSD component, mitigating tools in addition to those available for required safe shutdown components applymay be credited as an alternate to those available for required for safe

Comment [RFR18]: This overlaps with re-designing the system - it's not in addition to. A fire area that doesn't meet Appendix R can be re-designed to meet III.G.2 as one option. Re-design for III.G.1 is also an option.

[2] Licensing Citation: Waterford III Submittal to NRR dated February 7, 1985, Item No. 5 on page 3. Susquehanna Steam Electric Station NRC Question 40.97 paragraph 3a. Wolf Creek/Callaway SSER 5 Section 9.5.1.5 second paragraph.

shutdown components. Refer to Figure 1-1 and Appendix H for additional details. One of the mitigating tools for an important to SSD circuit component is the use of an operator manual action. If an operator manual action is relied upon as the mitigating tool, then it must meet the regulatory acceptance criteria related to operator manual actions. Refer to Appendix E for additional information related to the regulatory acceptance criteria for operator manual actions.

The process of identifying and mitigating impacts to the required safe shutdown path(s) described above is explained in more detail throughout this document.

1.3.3 RISK SIGNIFICANCE METHODS

The Resolution Methodology for determining the Plant Specific List of MSOs is contained in Chapter 4. Refer to Chapter 4 for additional details. The method details both the determination of applicable plant-specific MSOs and the disposition/mitigation of the MSOs using either deterministic methods, Fire Modeling or risk (e.g. Focused Scope Fire PRA) methods. The use of risk significance methods, such as a focused-scope Fire PRA is documented in Chapter 5.

2 APPENDIX R REQUIREMENTS AND CONSIDERATIONS

This section provides a general overview of the Appendix R regulatory requirements including the criteria for classifying the various shutdown methods. It describes the distinctions between redundant, alternative and dedicated shutdown capabilities and provides guidance for implementing these shutdown methods. In addition, the considerations dealing with a loss of offsite power and associated circuits are also discussed. Refer to Figure 2-1.

2.1 REGULATORY REQUIREMENTS

10 CFR 50 Appendix A, General Design Criterion 3 establishes the overarching goals of NRC's fire protection requirements.

> *Criterion 3 -- Fire protection.* Structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Noncombustible and heat resistant materials shall be used wherever practical throughout the unit, particularly in locations such as the containment and control room. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on structures, systems, and components important to safety. Firefighting systems shall be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components.

10 CFR 50 Appendix R Section III.G establishes the regulatory requirements for protecting structures, systems and components important to safety, in order to satisfy the first sentence of GDC 3. Sections III.G.1 and III.G.2 discuss the requirements for "required for hot shutdown" and "important to safe shutdown" and Section III.G.3 discusses the requirements for "alternative or dedicated" shutdown. The requirements for each of these shutdown classifications will be considered separately.

Comment [d19]: PQ: In fact, 10 CFR 50.48 states that Appendix R establishes the program to satisfy Criterion 3. Section III.G only establishes the safe shutdown requirements to address the third level of defense in depth.

The following sections discuss the regulations and distinctions regarding redundant shutdown methods. Requirements specifically for alternative/dedicated shutdown methods that are different from those used for redundant shutdown methods are discussed in Appendix D to this document:

Requirements for Redundant Safe Shutdown

Section III.G.1 provides the requirements for fire protection of safe shutdown capability and states the following:

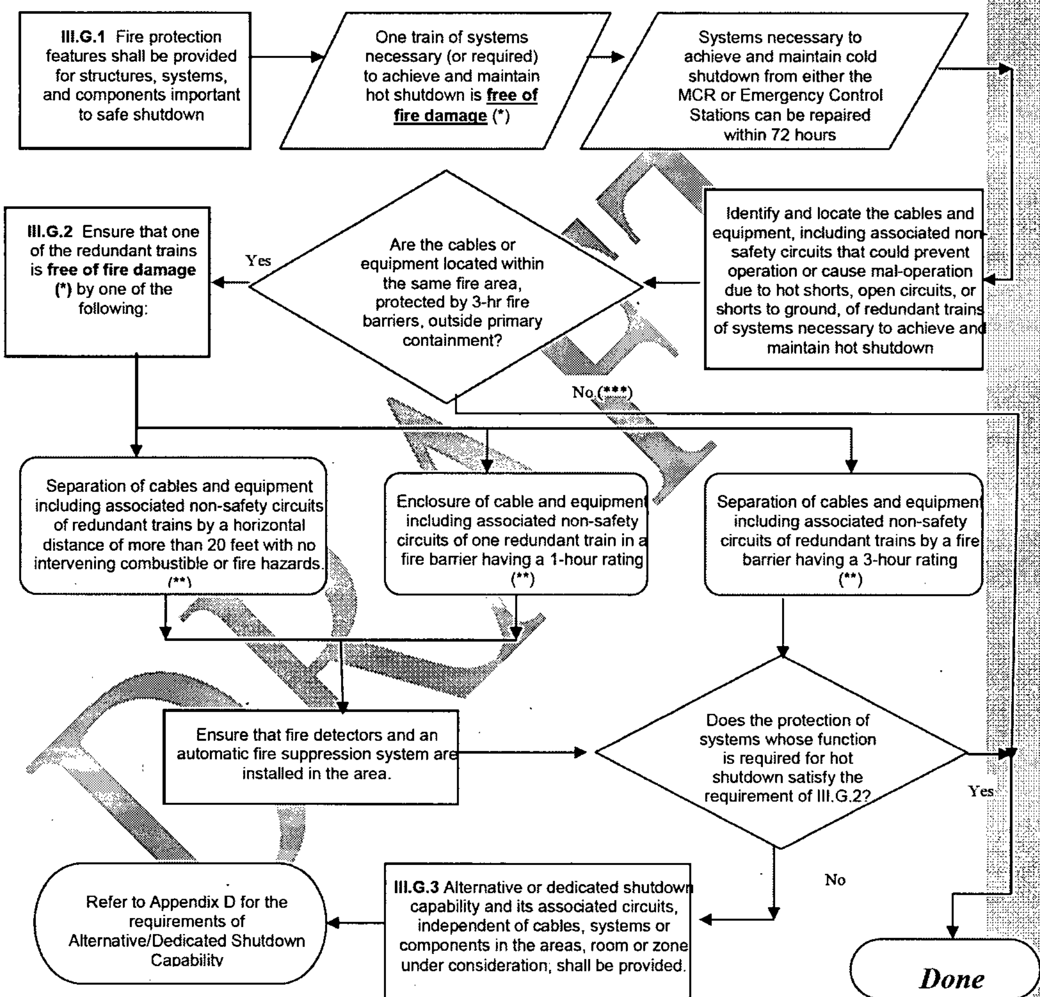
III. G. Fire protection of safe shutdown capability.

1. Fire protection features shall be provided for structures, systems, and components important to safe shutdown. These features shall 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.

Figure 2-1
Appendix R Requirements Flowchart



(*) "Free of Fire Damage" is achieved when the structure, system or component under consideration is capable of performing its intended function during and after the postulated fire, as needed

(**) Exemption Requests, Deviation Requests, LARs, GL 86-10 Fire Hazards Evaluations or Fire Protection Design Change Evaluations may be developed as necessary.

(***) For non-inerted containments, provide one of the protection methods identified in Appendix R Section III.G.2 (a), (b), or (c)or provide for 20 ft separation with no intervening combustibles or fire hazards, fire detection and automatic suppression, systems. or non-combustible radiant energy shields as specified in Appendix R Section III.G.2 (d), (e), or (f)

In Section III.G.1 there are no functional requirements specifically itemized for the structures, systems or components. The only requirements identified are those to initially achieve and maintain hot shutdown and to subsequently achieve cold shutdown once any required repairs have been completed.

Section III.G.1 establishes the requirement to ensure that adequate fire protection features exist to assure that one train of systems necessary to achieve and maintain hot shutdown is free of fire damage. Section III.G.1 presumes that some preexisting fire protection features have been provided, such as barriers (previously approved by the NRC under Appendix A to BTP APCSB 9.5-1).

III.G.2 Except as provided for in paragraph G.3 of this section, where cables or equipment, including associated non-safety circuits that could prevent operation or cause mal-operation due to hot shorts, open circuits, or shorts to ground, of redundant trains of systems necessary to achieve and maintain hot shutdown conditions are located within the same fire area outside of primary containment, one of the following means of ensuring that one of the redundant trains is free of fire damage shall be provided:

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 combustible or fire hazards. In addition, fire detectors and automatic fire suppression system shall be installed in the fire area; or

c. Enclosure of cable 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;

Inside non-inerted containments one of the fire protection means specified above or one of the following fire protection means shall be provided:

d. 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;

e. Installation of fire detectors and an automatic fire suppression system in the fire area; or

f. Separation of cables and equipment and associated non-safety circuits of redundant trains by a noncombustible radiant energy shield.

Section III.G.2 provides separation requirements that must be utilized where redundant trains are located in the same fire area. To comply with the regulatory requirements in Section III.G.1 and 2, the analyst must determine which fire barriers are needed it is necessary to maintain those barriers previously reviewed and approved by the NRC under Appendix A to APCSB 9.5-1 ~~that~~to ~~that~~ provide separation essential for safe shutdown (this may include active fire suppression equipment originally credited for barrier functionality). Where redundant trains of systems necessary to achieve hot shutdown are located in the same fire area outside of primary containment, one must provide fire protection features consistent with the requirements of Section III.G.2.a, b, or c (III.G.2.d, e, and f are also acceptable options inside non-inerted containments) to protect structures, systems, components and cables for one train capable of achieving and maintaining hot shutdown conditions. One must also assure that any repairs required to equipment necessary to achieve and maintain cold shutdown, from either the MCR or emergency control station(s) can be made within 72 hours.

Depending on a plant's current licensing basis and Fire Protection License Condition, exemptions, or deviations, LARs or GL 86-10 fire hazards analyses and/or fire protection design change evaluations may be used to justify configurations that meet the underlying goals of Appendix R but not certain specific requirements.

Comment [h20]: This statement may not be true. Appendix R analysis may credit different barriers than 9.5-1 Appendix A. It is necessary to define those fire barriers needed to provide the separation credited in the Post-Fire Safe Shutdown Analysis.

2.2 REGULATORY GUIDANCE ON ASSOCIATED CIRCUITS

2.2.1 To ensure that safe shutdown systems remain available to perform their intended functions, the post-fire safe shutdown analysis also requires that other failures be evaluated to ensure that the safe shutdown system functions are not defeated. The analysis requires that consideration be given to cable failures that may cause spurious operations resulting in unwanted conditions. Also, circuit failures resulting in the loss of support systems such as the electrical power supply from improperly coordinated circuit protective devices must be considered. As defined in Generic Letter 81-12, these types of circuits are collectively referred to as "Associated circuits of concern".[3]

2.2.2 Associated circuits need to be evaluated to determine if cable faults can prevent the operation or cause the mal-operation of redundant systems used to achieve and maintain hot shutdown or adversely affect the post-fire safe shutdown capability.

From time to time, the NRC has issued Staff Positions (e.g., memorandum, Information Notices, Generic Letters, inspection findings) documenting their positions as to what systems they consider necessary to achieve and maintain hot shutdown conditions, as well as documenting what types of fire-induced faults should be considered credible for affecting these necessary systems.

2.2.3 NRC GL 81-12, Fire Protection Rule (45 FR 76602, November 19, 1980), dated February 20, 1981, provides additional clarification related to associated circuits of concernnon-safety circuits that can either prevent operation or cause mal-operation of redundant safe shutdown trains. With respect to these associated circuits of concern, GL 81-12 describes

Comment [RFR21]: As noted in RIS 2005-30, only "associated circuits of concern" are clearly defined in NRC regulatory documents. The term "associated circuits" has been interpreted in a number of ways and never specifically defined in NRC documents and should not be used. This comment applies throughout the document.

Comment [d22]: PQ: GL 81-12 was to address Section III.G.3, Alternative of Dedicated Safe shutdown. Since this discussion is in the Redundant SSD portion of NEI 00-01, the implication is that the guidelines somehow apply. Enclosure 2 to GL 81-12, Request for Additional Information, Paragraph one states: "1. Section III.G of Appendix R to 10 CFR Part 50 requires cabling for or associated with redundant safe shutdown systems necessary to achieve and maintain hot shutdown conditions be separated by fire barriers having a three-hour fire rating or equivalent protection (see Section III.G.2 of Appendix R)." The associated circuits for III.G.2 must be protected in accordance with III.G.2 to meet the regulation.

[3] See the definition of "associated circuits of concern" in GL 81-12.

three types of associated circuits of concern. The Clarification of Generic Letter 81-12 defines associated circuits of concern as those cables and equipment that:

a). Have a physical separation less than that required by Section III.G.2 of Appendix R, and:

b). Have either:

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

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

iii) A common enclosure (e.g., raceway, panel, junction) with the shutdown cables (redundant and alternative) and,

(1) are not electrically protected by circuit breakers, fuses or similar devices, or

(2) will not prevent propagation of the fire into the common enclosure.

Although protecting the fire-induced failures of associated circuits of concern is required, to reinforce that Generic Letter 81-12 simply provides guidance rather than requirements, the Clarification of Generic Letter 81-12 further states the following regarding alternatives for protecting the safe shutdown capability:

The guidelines for protecting the safe shutdown capability from fire-induced failures of associated circuits are not requirements. These guidelines should be used only as guidance when needed. These guidelines do not limit the alternatives available to the licensee for protecting the safe shutdown capability. All proposed methods for protection of the shutdown capability from fire-induced failures will be evaluated by the [NRC] staff for acceptability.

2.3 REGULATORY INTERPRETATION ON LOSS OF OFFSITE POWER

2.3.1 The loss of offsite power has the potential to affect safe shutdown capability. In addition, the regulatory requirements for offsite power differ between the redundant and alternative/dedicated shutdown capability. Therefore, consideration must be given for the loss of offsite power when evaluating its effect on safe shutdown. The Appendix R requirement to consider a loss of offsite power is specified in Section III.L.3 as follows:

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 post-fire 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.*

2.3.2 Alternative/dedicated systems must demonstrate shutdown capability where offsite power is available and where offsite power is not available for 72 hours. 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 shall be provided. Equipment and systems used after 72 hours may be powered by offsite power only.

2.3.3 For redundant shutdown, offsite power may be credited if demonstrated to be free of fire damage, similar to other safe shutdown systems.

2.3.4 If offsite power is postulated to be lost for a particular fire area, and is not needed for the required safe shutdown path for 72 hours, actions necessary for its restoration are considered to be performed under the purview of the emergency response organization and do not require the development of specific recovery strategies or procedures in advance.

2.3.5 Since in an actual fire event offsite power may or may not be available, the potential availability of offsite power should also be considered to confirm that it does not pose a more challenging condition. For example, additional electric heat loads may affect HVAC strategies.

3 DETERMINISTIC METHODOLOGY

This section discusses a generic deterministic methodology and criteria that licensees can use to perform a post-fire safe shutdown analysis to address regulatory requirements. The plant-specific analysis approved by NRC is reflected in the plant's licensing basis. The methodology described in this section is an acceptable method of performing a post-fire safe shutdown analysis. This methodology is depicted in Figure 3-1. Other methods acceptable to NRC may also be used. Regardless of the method selected by an individual licensee, the criteria and assumptions provided in this guidance document may apply. The methodology described in Section 3 is based on a computer database oriented approach, which is utilized by several licensees to model Appendix R data relationships. This guidance document, however, does not require the use of a computer database oriented approach.

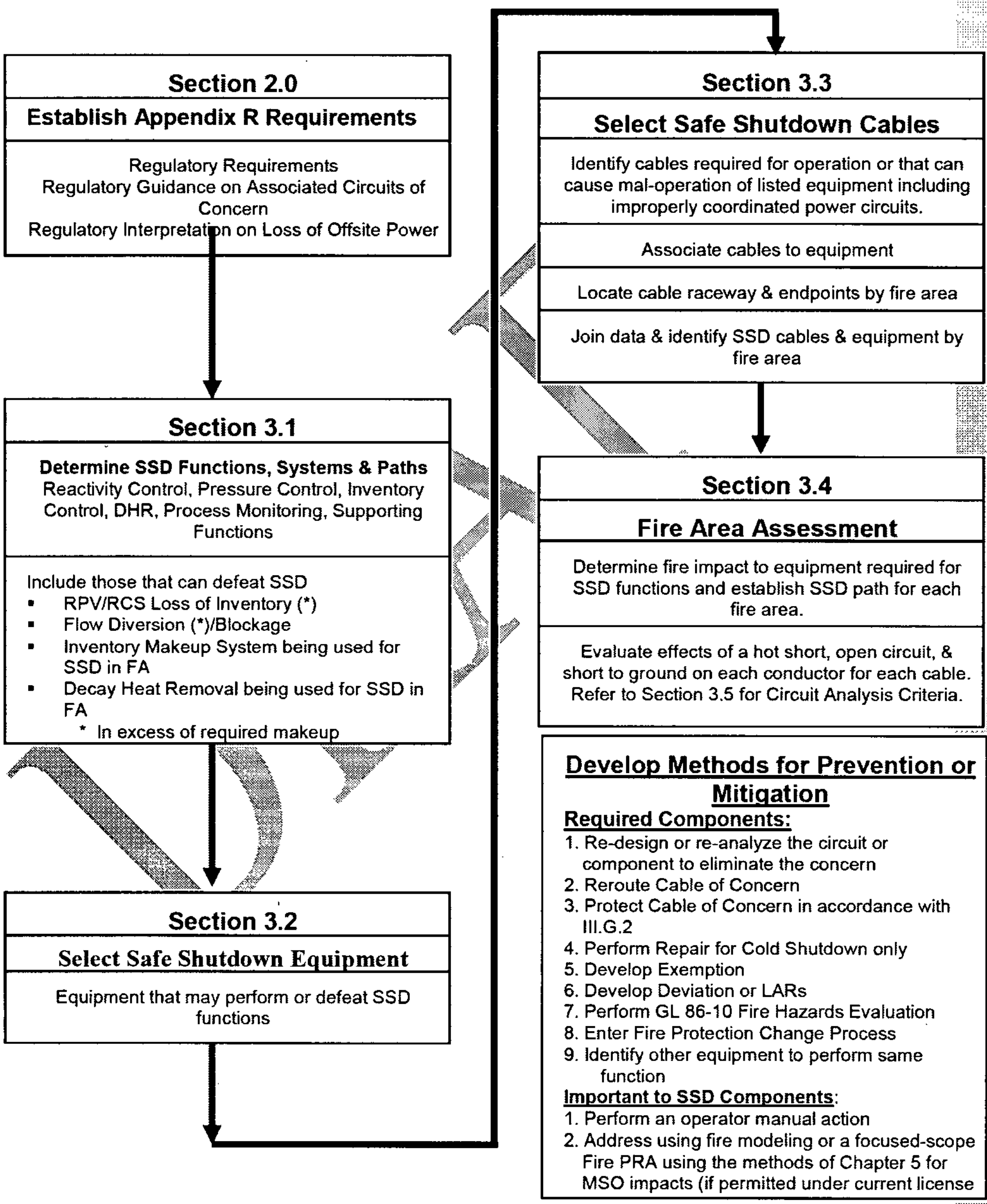
The requirements of Appendix R Sections III.G.1, III.G.2 and III.G.3 apply to equipment and cables required for achieving and maintaining safe shutdown in any fire area. Although equipment and cables for fire detection and suppression systems, communications systems and 8-hour emergency lighting systems are important features, this guidance document does not address them. The requirements of Appendix R Section III.G.2 do not apply to the circuits for fire detection and suppression systems, communications systems and 8-hour emergency lighting systems.

Additional information is provided in Appendix B to this document related to the circuit failure criteria to be applied in assessing the impact of MSOs on post-fire safe shutdown. The criteria in Appendix B is for MSOs only and it does not supersede the criteria contained in Section 3.5.1.1 for assessing the potential affects of fire-induced impacts to individual components on the required safe shutdown path for a particular fire area. Chapter 4 provides the Resolution Methodology for determining the Plant Specific List of MSOs to be evaluated. Chapter 5 provides a focused-scope Fire PRA risk methodology for assessing, on an individual basis, the risk significance of any MSOs determined to be impacted within a common plant fire area. The appropriate use of these tools for mitigating the effects of fire-induced circuit failures for this section and for the MSOs addressed in Chapter 4 and Appendix G are discussed in Appendix H.

3.1 SAFE SHUTDOWN SYSTEMS AND PATH DEVELOPMENT

This section discusses the identification of systems necessary to perform the required safe shutdown functions. It also provides information on the process for combining these systems into safe shutdown paths. Appendix R Section III.G.1.a requires that the capability to achieve and maintain hot shutdown be free of fire damage. Appendix R Section III.G.1.b requires that repairs to systems and equipment necessary to achieve and maintain cold shutdown be completed within 72 hours. This section provides some guidance on classifying components as either required or important to SSD circuit components. It also provides some guidance on the tools available for mitigating the effects of fire-induced circuit failures to each of these classes of equipment. For a more detailed discussion of the topic of required and important to SSD components refer to Appendix H.

Figure 3-1
Deterministic Guidance Methodology Overview



The goal of post-fire safe shutdown is to assure that a one train of shutdown systems, structures, and components remains free of fire damage for a single fire in any single plant fire area. This goal is accomplished by determining those functions important to achieve and maintain hot shutdown. Safe shutdown systems are selected so that the capability to perform these required functions is a part of each safe shutdown path. The functions important to post-fire safe shutdown generally include, but are not limited to the following:

- Reactivity control
- Pressure control systems
- Inventory control systems
- Decay heat removal systems
- Process monitoring (as defined in NRC Information Notice 84-09)
- Support systems
  - Electrical power and control systems
  - Component Cooling systems, including room cooling
  - Component Lubrication systems

Comment [e23]: HVAC

These functions are of importance because they have a direct bearing on the safe shutdown goal of being able to achieve and maintain hot shutdown, which ensures the integrity of the fuel, the reactor pressure vessel and the primary containment. If these functions are preserved, then the plant will be safe because the fuel, the reactor and the primary containment will not be damaged. By assuring that this equipment is not damaged and remains functional, the protection of the health and safety of the public is assured.

The components required to perform these functions are classified as required for hot shutdown components. These components are necessary and sufficient to perform the required safe shutdown functions assuming that fire-induced impacts to other plant equipment/cables do not occur. Since fire-induced impacts to other plant equipment/cables can occur in the fire condition, these impacts must also be addressed. The components not necessary to complete the required safe shutdown functions, but which could be impacted by the fire and cause a subsequent impact to the required safe shutdown components are classified as either required for hot shutdown or important to SSD components. Depending on the classification of the components, the tools available for mitigating the affects of fire-induced damage vary. The available tools are generally discussed in this section and in detail in Appendix H. The classification of a component or its power or control circuits may vary form from fire area to fire area. Therefore, the required safe shutdown path for any given fire area is comprised of required for hot shutdown components and important to SSD components. The distinction and classification for each required safe shutdown path for each fire area should be discernible in the post-fire safe shutdown analysis.

Generic Letter 81-12 specifies consideration of circuits with the potential for spurious equipment operation and/or loss of power source, and the common enclosure failures. As described above, spurious operations/actuations can affect the accomplishment of the required safe shutdown functions listed above. Typical examples of the effects of the spurious operations of concern are the following:

- A loss of reactor pressure vessel/reactor coolant inventory in excess of the safe shutdown makeup capability
- A flow loss or blockage in the inventory makeup or decay heat removal systems being used for the required safe shutdown path.

Spurious operations are of concern because they have the potential to directly affect the ability to achieve and maintain hot shutdown, which could affect the fuel and cause damage to the reactor pressure vessel or the primary containment. To address the issue of multiple spurious operations, Chapter 4 provides a Resolution Methodology for developing a Plant Specific List of MSOs for evaluation. Appendix B provides the circuit failure criteria applicable to the evaluation of the Plant Specific list of MSOs.

Common power source and common enclosure concerns could also affect the these safe shutdown train and must be addressed.

Fire-induced impacts to cables and components classified as important to SSD may be mitigated using a different set of tools as well asthan those classified as required for hot shutdown components. For important to SSD component failures, operator manual actions, fire modeling and/or a focused-scope fire PRA may also be used to mitigate the impact. (Focused-scope fire PRAs must are not be permitted in the ~~Plants~~PlantsPlant's current License Basis. If not, aA risk-informed License Amendment Request (LAR) may will be necessary).

3.1.1 CRITERIA/ASSUMPTIONS

The following criteria and assumptions may should be considered, as applicable, when identifying systems available and necessary to perform the required safe shutdown functions and combining these systems into safe shutdown paths. This list provides recognized examples of criteria/assumptions but should not be considered an all-inclusive list. The final set of criteria/assumptions should be based on regulatory requirements and the performance criteria for post-fire safe shutdown for each plant.-

3.1.1.1 [BWR] GE Report GE-NE-T43-00002-00-01-R01 entitled "Original Safe Shutdown Paths For The BWR" addresses the systems and equipment originally designed into the GE boiling water reactors (BWRs) in the 1960s and 1970s, that can be used to achieve and maintain safe shutdown per Section III.G.1 of 10 CFR 50, Appendix R. Any of the shutdown paths (methods) described in this report are considered to be acceptable methods for achieving redundant safe shutdown.

3.1.1.2 [BWR] GE Report GE-NE-T43-00002-00-03-R01 provides a discussion on the BWR Owners' Group (BWROG) position regarding the use of Safety Relief Valves (SRVs) and low pressure systems (LPCI/CS) for safe shutdown. The BWROG position is that the use of SRVs and low pressure systems is an acceptable methodology for achieving redundant safe shutdown in accordance with the requirements of 10 CFR 50 Appendix R Sections III.G.1 and III.G.2. The NRC has accepted the BWROG position and issued an SER dated Dec. 12, 2000.

3.1.1.3 [PWR] Generic Letter 86-10, Enclosure 2, Section 5.3.5 specifies that hot shutdown can be maintained without the use of pressurizer heaters (i.e., pressure control is provided by controlling the makeup/charging pumps). Hot shutdown conditions can be maintained via natural circulation of the RCS through the steam generators. The cooldown rate must be controlled to prevent the formation of a bubble in the reactor head. Therefore, feedwater (either auxiliary or emergency) flow rates as well as steam release must be controlled.

3.1.1.4 The classification of shutdown capability as alternative/dedicated shutdown is made independent of the selection of systems used for shutdown. Alternative/dedicated shutdown capability is determined based on an inability to assure the availability of a redundant safe shutdown path. Compliance to the separation requirements of Sections III.G.1 and III.G.2 may be supplemented by the use of operator manual actions to the extent allowed by the regulations and the licensing basis of the plant (see Appendix E), repairs (cold shutdown only), exemptions, deviations, GL 86-10 fire hazards analyses or fire protection design change evaluations permitted by GL 86-10, as appropriate. These may also be used in conjunction with alternative/dedicated shutdown capability. A discussion of time zero for the fire condition, as it relates to operator manual actions and repairs, is contained in Appendix E.

3.1.1.5 At the onset of the postulated fire, all safe shutdown systems (including applicable redundant trains) are assumed operable and available for post-fire safe shutdown. Systems are assumed to be operational with no repairs, maintenance, testing, Limiting Conditions for Operation, etc. in progress. The units are assumed to be operating at full power under normal conditions and normal lineups.

3.1.1.6 No Final Safety Analysis Report accidents or other design basis events (e.g. loss of coolant accident, earthquake), single failures or non-fire-induced transients need be considered in conjunction with the fire.

3.1.1.7 For the case of redundant shutdown, offsite power may be credited if demonstrated to be free of fire damage. Offsite power should be assumed to remain available for those cases where its availability may adversely impact safety (i.e., reliance cannot be placed on fire causing a loss of offsite power if the consequences of offsite power availability are more severe than its presumed loss). No credit should be taken for a fire causing a loss of offsite power. For areas where train separation cannot be achieved and alternative shutdown capability is necessary, shutdown must be demonstrated both where offsite power is available and where offsite power is not available for 72 hours.

3.1.1.8 Post-fire safe shutdown systems and components are not required to be safety-related.

3.1.1.9 The post-fire safe shutdown analysis assumes a 72-hour coping period starting with a reactor scram/trip. Fire-induced impacts that provide no adverse consequences to hot shutdown within this 72-hour period need not be included in the post-fire safe shutdown analysis. At least one train can be repaired or made operable within 72 hours using onsite capability to achieve cold shutdown.

3.1.1.10 Manual initiation from the main control room or emergency control stations of systems required to achieve and maintain safe shutdown is acceptable where permitted by current regulations or approved by NRC (See Appendix E); automatic initiation of systems selected for safe shutdown is not required but may be included as an option, if the additional cables and equipment are also included in the analysis. However, spurious actuation of automatic systems (Safety Injection, Auxiliary Feedwater, High Pressure Coolant Injection, Reactor Core Isolation Cooling, etc.) due to fire damage should be evaluated.

3.1.1.11 Where a single fire can impact more than one unit of a multi-unit plant, the ability to achieve and maintain safe shutdown for each affected unit must be demonstrated.

3.1.2 SHUTDOWN FUNCTIONS

The following discussion on each of these shutdown functions provides guidance for selecting the systems and equipment required for hot shutdown. For additional information on BWR system selection, refer to GE Report GE-NE-T43-00002-00-01-R01 entitled "Original Safe Shutdown Paths for the BWR."

3.1.2.1 Reactivity Control

[BWR] Control Rod Drive System

The safe shutdown performance and design requirements for the reactivity control function can be met without automatic scram/trip capability. Manual scram/reactor trip is credited. The post-fire safe shutdown analysis must only provide the capability to manually scram/trip the reactor. Each licensee should have an operator manual action to either vent the instrument air header or to remove RPS power in their post-fire safe shutdown procedures. The presence of this action precludes the need to perform circuit analysis for the reactivity control function and is an acceptable way to accomplish this function.

Comment [h24]: This action becomes a "time critical" Operator Manual Action, the timing of which must be justified.

[PWR] Makeup/Charging

There must be a method for ensuring that adequate shutdown margin is maintained from initial reactor SCRAM to cold shutdown conditions, by controlling Reactor Coolant System temperature and ensuring borated water is utilized for RCS makeup/charging.

Comment [h25]: RCS temperature must be controlled since most PWRs can not maintain adequate shutdown margin without adding additional boron.

3.1.2.2 Pressure Control Systems

The systems discussed in this section are examples of systems that can be used for pressure control. This does not restrict the use of other systems for this purpose.

[BWR] Safety Relief Valves (SRVs)

Initial pressure control may be provided by the SRVs mechanically cycling at their setpoints (electrically cycling for EMRVs). Mechanically-actuated SRVs require no electrical analysis to perform their overpressure protection function. The SRVs may also be opened to maintain hot shutdown conditions or to depressurize the vessel to allow injection using low pressure systems. These are operated manually. Automatic initiation of the Automatic Depressurization System (ADS) is not a required function. Automatic initiation of the ADS may be credited, if available. If automatic ADS is not available and use of ADS is desired, an alternative means of ~~initiationg~~initiation of ADS separate from the automatic initiation logic for accomplishing the pressure control function should be provided.

[PWR] Makeup/Charging

RCS pressure is controlled by controlling the rate of charging/makeup to the RCS. Although utilization of the pressurizer heaters and/or auxiliary spray reduces operator burden, neither component is required to provide adequate pressure control. Pressure reductions are made by allowing the RCS to cool/shrink, thus reducing pressurizer level/pressure. Pressure increases are made by initiating charging/makeup to maintain pressurizer level/pressure. Manual control of the related pumps is acceptable.

3.1.2.3 Inventory Control

[BWR] Systems selected for the inventory control function should be capable of supplying sufficient reactor coolant to achieve and maintain hot shutdown. Manual initiation of these systems is acceptable. Automatic initiation functions are not required. However, spurious actuation of automatic systems should be evaluated (High Pressure Coolant Injection, High Pressure Core Spray, Reactor Core Isolation Cooling, etc.)

[PWR]: Systems selected for the inventory control function should be capable of maintaining level to achieve and maintain hot shutdown. Typically, the same components providing inventory control are capable of providing pressure control. Manual initiation of these systems is acceptable. Automatic initiation functions are not required. However, spurious actuation of automatic systems should be evaluated (Safety Injection, High Pressure Injection, Auxiliary Feedwater, Emergency Feedwater, etc.).

3.1.2.4 Decay Heat Removal

[BWR] Systems selected for the decay heat removal function(s) should be capable of:

- Removing sufficient decay heat from primary containment, to prevent containment over-pressurization and failure.
- Satisfying the net positive suction head requirements of any safe shutdown systems taking suction from the containment (suppression pool).
- Removing sufficient decay heat from the reactor to achieve cold shutdown. (This is not a hot shutdown requirement.)

[PWR] Systems selected for the decay heat removal function(s) should be capable of:

- Removing sufficient decay heat from the reactor to reach hot shutdown conditions. Typically, this entails utilizing natural circulation in lieu of forced circulation via the reactor coolant pumps and controlling steam release via the Atmospheric Dump valves.
- Removing sufficient decay heat from the reactor to reach cold shutdown conditions. (This is not a hot shutdown requirement.)

This does not restrict the use of other systems.

3.1.2.5 Process Monitoring

The process monitoring function is provided for all safe shutdown paths. IN 84-09, Attachment 1, Section IX "Lessons Learned from NRC Inspections of Fire Protection Safe Shutdown Systems (10 CFR 50 Appendix R)" provides guidance on the instrumentation acceptable to and preferred by the NRC for meeting the process monitoring function. This instrumentation is that which monitors the process variables necessary to perform and control the functions specified in Appendix R Section III.L.1. Such instrumentation must be demonstrated to remain unaffected by the fire. The IN 84-09 list of process monitoring is applied to alternative/dedicated shutdown (III.G.3). The use of this same list for III.G.2 redundant Post-Fire Safe Shutdown is acceptable, but the analyst needs to review the specific license basis for the plant under evaluation. In general, process monitoring instruments similar to those listed below are needed to successfully use existing operating procedures (including Abnormal Operating Procedures).

<u>BWR</u>

- Reactor coolant level and pressure
- Suppression pool level and temperature
- Emergency or isolation condenser level
- Diagnostic instrumentation for safe shutdown systems
- Level indication for tanks needed for safe shutdown

<u>PWR</u>

- Reactor coolant temperature (hot leg / cold leg)
- Pressurizer pressure and level
- Neutron flux monitoring (source range)
- Level indication for tanks needed for safe shutdown
- Steam generator level and pressure
- Diagnostic instrumentation for safe shutdown systems

The specific instruments required may be based on operator preference, safe shutdown procedural guidance strategy (symptomatic vs. prescriptive), and systems and paths selected for safe shutdown.

3.1.2.6 Support Systems

3.1.2.6.1 Electrical Systems

<u>**AC Distribution System**</u>

Power for the Appendix R safe shutdown equipment is typically provided by a medium voltage system such as 4.16 KV Class 1E busses either directly from the busses or through step down transformers/load centers/distribution panels for 600, 480 or 120 VAC loads. For redundant safe shutdown performed in accordance with the requirements of Appendix R Section III.G.1 and 2, power may be supplied from either offsite power sources or the emergency diesel generator depending on which has been demonstrated to be free of fire damage. No credit should be taken for any the beneficial effects of a fire causing a loss of offsite power. Refer to Section 3.1.1.7.

<u>**DC Distribution System**</u>

Typically, the 125VDC distribution system supplies DC control power to various 125VDC control panels including switchgear breaker controls. The 125VDC distribution panels may also supply power to the 120VAC distribution panels via static inverters. These distribution panels may supply power for instrumentation necessary to complete the process monitoring functions.

For fire events that result in an interruption of power to the AC electrical bus, the station batteries are necessary to supply any required control power during the interim time period required for the diesel generators to become operational. Once the diesels are operational, the 125VDC distribution system can be powered from sources feed from the diesels through the battery chargers.

[BWR] Certain plants are also designed with a 250VDC Distribution System that supplies power to Reactor Core Isolation Cooling and/or High Pressure Coolant Injection equipment.

The DC control centers may also supply power to various small horsepower Appendix R safe shutdown system valves and pumps. If the DC system is relied upon to support safe shutdown without battery chargers being available, it must be verified that sufficient battery capacity exists to support the necessary loads for sufficient time (either until power is restored, or the loads are no longer required to operate).

3.1.2.6.2 Cooling Systems

Various cooling water systems are required to support safe shutdown system operation, based on plant-specific considerations. Typical uses include:

- RHR/SDC/DH Heat Exchanger cooling water
- Safe shutdown pump cooling (seal coolers, oil coolers)
- Diesel generator cooling

3.1.2.6.3 HVAC Systems

HVAC Systems may be required to assure that safe shutdown equipment remains within its operating temperature range, as specified in manufacturer's literature or demonstrated by suitable test methods, and to assure protection for plant operations staff from the effects of fire (smoke, heat, toxic gases, and gaseous fire suppression agents).

HVAC systems, however, are not required to support post-fire safe shutdown in all cases. The need for HVAC system operation is based on plant-specific configurations and plant specific heat loads. Typical potential uses include:

- Main control room, cable spreading room, relay room
- ECCS pump compartments
- Diesel generator rooms
- Switchgear rooms

Plant-specific evaluations are necessary to determine which HVAC systems could be required or useful in supporting post-fire safe shutdown. Transient temperature response analyses are often utilized to demonstrate that specific HVAC systems would or would not be required. If HVAC systems are credited, the potential for adverse fire effects to the HVAC system must also be considered, including:

- Dampers closing due to direct fire exposure or due to hot gases flowing through ventilation ducts from the fire area to an area not directly affected by the fire. Where provided, smoke dampers should consider similar effects from smoke.
- Recirculation or migration of toxic conditions (e.g., smoke from the fire, suppressants such as Carbon Dioxide).

In certain situations, adequate time exists to open doors to provide adequate cooling to allow continued equipment operation. Therefore, the list of required safe shutdown components as it relates to HVAC Systems may be determined based on transient temperature analysis. Should this analysis demonstrate that adequate time exists to open doors to provide the necessary cooling, this is an acceptable approach to achieving HVAC Cooling. Only those components whose operation is required to provide

Comment [RFR26]: The analysis would also have to demonstrate that adequate cooling can be achieved by opening the door.

immediate HVAC Cooling for required safe shutdown components are considered themselves to be required safe shutdown components. This latter set of HVAC Cooling Components are required to meet the criteria for required safe shutdown components with regard to the available mitigating tools.

Comment [h27]: Need to define what "immediate" is. Within 15 minutes? 30 minutes?

3.1.3 METHODOLOGY FOR SHUTDOWN SYSTEM SELECTION

Refer to Figure 3-2 for a flowchart illustrating the various steps involved in selecting safe shutdown systems and developing the shutdown paths.

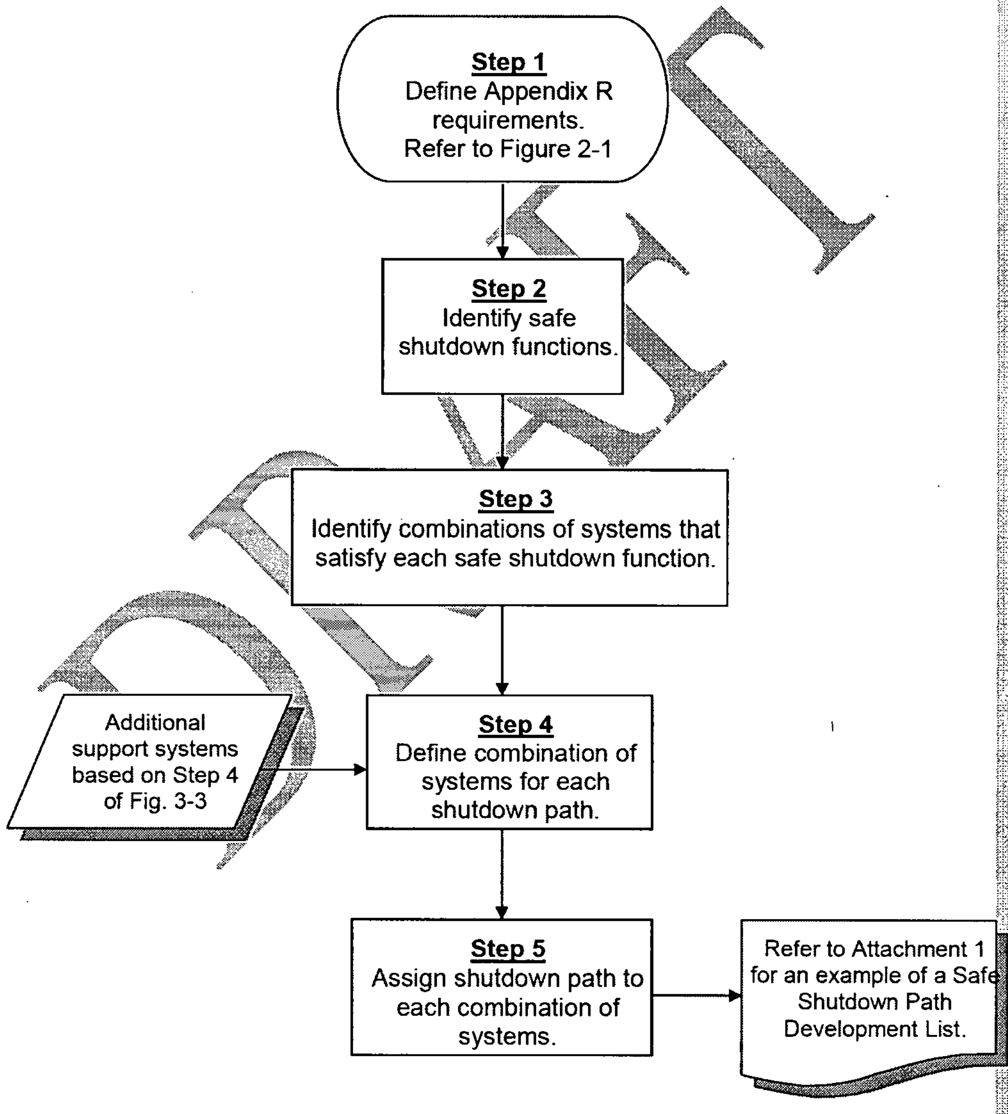
The following methodology may be used to define the safe shutdown systems and paths for an Appendix R analysis:

3.1.3.1 Identify safe shutdown functions

Review available documentation to obtain an understanding of the available plant systems and the functions required to achieve and maintain safe shutdown. Documents such as the following may be reviewed:

- Operating Procedures (Normal, Emergency, Abnormal)
- System descriptions
- Fire Hazard Analysis
- Single-line electrical diagrams
- Piping and Instrumentation Diagrams (P&IDs)
- [BWR] GE Report GE-NE-T43-00002-00-01-R02 entitled "Original Shutdown Paths for the BWR"

Figure 3-2
Safe Shutdown System Selection and Path Development



3.1.3.2 Identify Combinations of Systems That Satisfy Each Safe Shutdown Function

Given the criteria/assumptions defined in Section 3.1.1, identify the available combinations of systems capable of achieving the safe shutdown functions of reactivity control, pressure control, inventory control, decay heat removal, process monitoring and support systems such as electrical and cooling systems (refer to Section 3.1.2). This selection process does not restrict the use of other systems. In addition to achieving the required safe shutdown functions, consider other equipment whose mal-operation or spurious operation could impact the required safe shutdown function. The components in this latter set are classified as either required for hot shutdown or as important to SSD as explained in Appendix H.

3.1.3.3 Define Combination of Systems for Each Safe Shutdown Path

Select combinations of systems with the capability of performing all of the required safe shutdown functions and designate this set of systems as a safe shutdown path. In many cases, paths may be defined on a divisional basis since the availability of electrical power and other support systems must be demonstrated for each path. During the equipment selection phase, identify any additional support systems and list them for the appropriate path.

3.1.3.4 Assign Shutdown Paths to Each Combination of Systems

Assign a path designation to each combination of systems. The path will serve to document the combination of systems relied upon for safe shutdown in each fire area. Refer to Attachment 1 to this document for an example of a table illustrating how to document the various combinations of systems for selected shutdown paths.

3.2 SAFE SHUTDOWN EQUIPMENT SELECTION

The previous section described the methodology for selecting the systems and paths necessary to achieve and maintain safe shutdown for an exposure fire event (see Section 5.0 DEFINITIONS for "Exposure Fire"). This section describes the criteria/assumptions and selection methodology for identifying the specific safe shutdown equipment necessary for the systems to perform their Appendix R functions. The selected equipment should be related back to the safe shutdown systems that they support and be assigned to the same safe shutdown path as that system. The list of safe shutdown equipment will then form the basis for identifying the cables necessary for the operation or that can cause the mal-operation of the safe shutdown systems. For each path it will be important to understand which components are classified as required safe shutdown components and which are classified as associate circuit important to safe shutdown components. When evaluating the fire-induced impact to each affected cable/component in each fire area, this classification dictates the tools available for mitigation the affects.

Comment [RFR28]: See earlier comments regarding associated circuits.

3.2.1 CRITERIA/ASSUMPTIONS

Consider the following criteria and assumptions when identifying equipment necessary to perform the required safe shutdown functions:

3.2.1.1 Safe shutdown equipment can be divided into two categories. Equipment may be categorized as (1) primary components or (2) secondary components. Typically, the following types of equipment are considered to be primary components:

- Pumps, motor operated valves, solenoid valves, fans, gas bottles, dampers, unit coolers, etc.
- All necessary process indicators and recorders (i.e., flow indicator, temperature indicator, turbine speed indicator, pressure indicator, level recorder)
- Power supplies or other electrical components that support operation of primary components (i.e., diesel generators, switchgear, motor control centers, load centers, power supplies, distribution panels, etc.).

Secondary components are typically items found within the circuitry for a primary component. These provide a supporting role to the overall circuit function. Some secondary components may provide an isolation function or a signal to a primary component via either an interlock or input signal processor. Examples of secondary components include flow switches, pressure switches, temperature switches, level switches, temperature elements, speed elements, transmitters, converters, controllers, transducers, signal conditioners, hand switches, relays, fuses and various instrumentation devices.

Determine which equipment should be included on the Safe Shutdown Equipment List (SSEL). As an option, include secondary components with a primary component(s) that would be affected by fire damage to the secondary component. By doing this, the SSEL can be kept to a manageable size and the equipment included on the SSEL can be readily related to required post-fire safe shutdown systems and functions.

Comment [RFR29]: This is neither an assumption or criteria. Doesn't this paragraph belong in 3.2.2?

3.2.1.2 Assume that exposure fire damage to manual valves and piping does not adversely impact their ability to perform their pressure boundary or safe shutdown function (heat sensitive piping materials, including tubing with brazed or soldered joints, are not included in this assumption). Fire damage should be evaluated with respect to the ability to manually open or close the valve should this be necessary as a part of the post-fire safe shutdown scenario.

Comment [h30]: Post-fire coefficient of friction for rising stem valves can not be determined; Handwheel sizes and rim pulls are based on well lubricated stems. Any post-fire operation of a rising stem valve should be well justified using an engineering evaluation.

3.2.1.3 Assume that all components, including manual valves, are in their normal position as shown on P&IDs or in the plant operating procedures, that there are no LCOs in effect, that the Unit is operating at 100% power and that no equipment has been taken out of service for maintenance.

3.2.1.4 Assume that a check valve closes in the direction of potential flow diversion and seats properly with sufficient leak tightness to prevent flow diversion. Therefore, check valves do not adversely affect the flow rate capability of the safe shutdown systems being used for inventory control, decay heat removal, equipment cooling or other related safe shutdown functions.

3.2.1.5 Instruments (e.g., resistance temperature detectors, thermocouples, pressure transmitters, and flow transmitters) are assumed to fail upscale, midscale, or downscale as a result of fire damage, whichever is worse. An instrument performing a control function is assumed to provide an undesired signal to the control circuit.

Identify equipment that could spuriously operate or mal-operate and impact the performance of equipment on a required safe shutdown path during the equipment selection phase. Additionally, refer to Chapter 4 for the Resolution Methodology for determining the Plant Specific List of MSOs requiring evaluation.

Comment [RFR31]: This is neither an assumption or criteria. Doesn't this paragraph belong in 3.2.2?

Identify instrument tubing that may cause subsequent effects on instrument readings or signals as a result of fire. Determine and consider the fire area location of the instrument tubing when evaluating the effects of fire damage to circuits and equipment in the fire area.

Comment [RFR32]: This is neither an assumption or criteria. Doesn't this paragraph belong in 3.2.2?

3.2.2 METHODOLOGY FOR EQUIPMENT SELECTION

Refer to Figure 3-3 for a flowchart illustrating the various steps involved in selecting safe shutdown equipment.

Use the following methodology to select the safe shutdown equipment for a post-fire safe shutdown analysis:

3.2.2.1 Identify the System Flow Path for Each Shutdown Path

Mark up and annotate a P&ID to highlight the specific flow paths for each system in support of each shutdown path. Refer to Attachment 2 for an example of an annotated P&ID illustrating this concept.

3.2.2.2 Identify the Equipment in Each Safe Shutdown System Flow Path Including Equipment That May Spuriously Operate and Affect System Operation

Review the applicable documentation (e.g. P&IDs, electrical drawings, instrument loop diagrams) to assure that all equipment in each system's flow path has been identified. Assure that any equipment that could spuriously operate and adversely affect the desired system function(s) is also identified. Criteria for making the determination as to which of these components are to be classified as required for hot shutdown or as important to SSD is contained in Appendix H. If additional systems are identified which are necessary for the operation of the safe shutdown system under review, include these as required for hot shutdown systems. Designate these new systems with the same safe shutdown path as the primary safe shutdown system under review (Refer to Figure 3-1).

3.2.2.3 Develop a List of Safe Shutdown Equipment and Assign the Corresponding System and Safe Shutdown Path(s) Designation to Each.

Prepare a table listing the equipment identified for each system and the shutdown path that it supports. Identify any valves or other equipment that could spuriously operate and impact the operation of that safe shutdown system. Criteria for making the determination as to which of these components are to be classified as required for hot shutdown or as important to SSD is contained in Appendix H. Assign the safe shutdown path for the affected system to this equipment. During the cable selection phase, identify additional equipment required to support the safe shutdown function of the path (e.g., electrical distribution system equipment). Include this additional equipment in the safe shutdown equipment list. Attachment 3 to this document provides an example of aan (SSEL). The SSEL identifies the list of equipment within the plant considered for post-fire safe shutdown and it documents various equipment-related attributes used in the analysis.

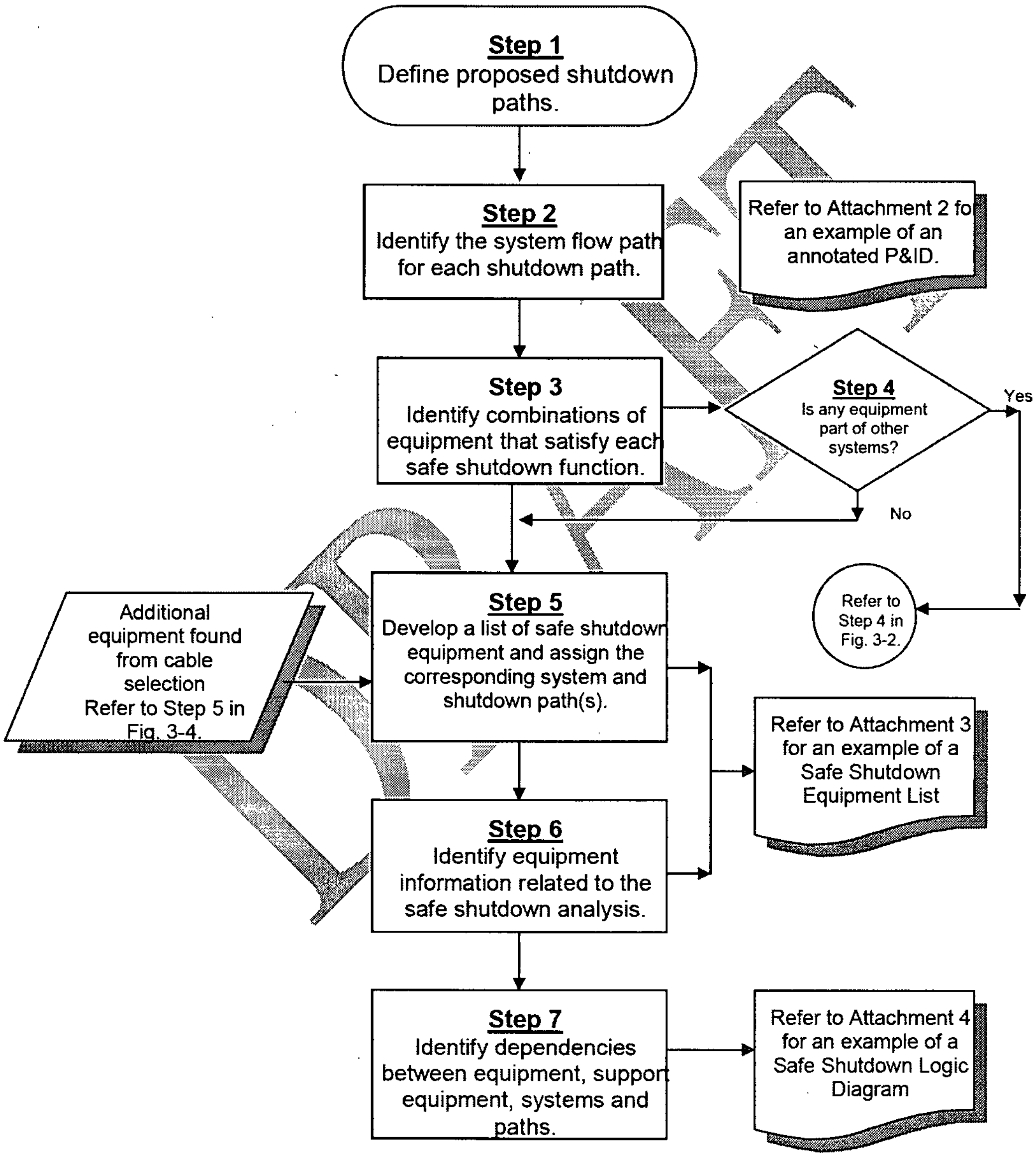
3.2.2.4 Identify Equipment Information Required for the Safe Shutdown Analysis

Collect additional equipment-related information necessary for performing the post-fire safe shutdown analysis for the equipment. In order to facilitate the analysis, tabulate this data for each piece of equipment on the SSEL. Refer to Attachment 3 to this document for an example of a SSEL. Examples of related equipment data should include the equipment type, equipment description, safe shutdown system, safe shutdown path, drawing reference, fire area, fire zone, and room location of equipment. Other information such as the following may be useful in performing the safe shutdown analysis: normal position, hot shutdown position, cold shutdown position, failed air position, failed electrical position, high/low pressure interface concern, and spurious operation concern. Criteria for making the determination as to which of these components are to be classified as required for hot shutdown or as important to SSD is contained in Appendix H.

3.2.2.5 Identify Dependencies Between Equipment, Supporting Equipment, Safe Shutdown Systems and Safe Shutdown Paths.

In the process of defining equipment and cables for safe shutdown, identify additional supporting equipment such as electrical power and interlocked equipment. As an aid in assessing identified impacts to safe shutdown, consider modeling the dependency between equipment within each safe shutdown path either in a relational database or in the form of a Safe Shutdown Logic Diagram (SSLD). Attachment 4 provides an example of a SSLD that may be developed to document these relationships.

Figure 3-3
Safe Shutdown Equipment Selection



3.3 SAFE SHUTDOWN CABLE SELECTION AND LOCATION

This section provides industry guidance on the recommended one acceptable approach to methodology and criteria for selecting safe shutdown cables and determining their potential impact on equipment required for achieving and maintaining safe shutdown of an operating nuclear power plant for the condition of an exposure fire. The Appendix R safe shutdown cable selection criteria are developed to ensure that all cables that could affect the proper operation or that could cause the mal-operation of safe shutdown equipment are identified and that these cables are properly related to the safe shutdown equipment whose functionality they could affect. Through this cable-to-equipment relationship, cables become part of the safe shutdown path assigned to the equipment affected by the cable. The classification of a cable as either an important to SSD circuit cable or a required safe shutdown cable is also derived from the classification applied to the component that it supports. This classification can vary from one fire area to another depending on the approach used to accomplish post-fire safe shutdown in the area. Refer to Appendix H for the criteria to be used for classifying required and important to SSD components.

3.3.1 CRITERIA/ASSUMPTIONS

To identify an impact to safe shutdown equipment based on cable routing, the equipment must have cables that affect it identified. Carefully consider how cables are related to safe shutdown equipment so that impacts from these cables can be properly assessed in terms of their ultimate impact on safe shutdown components, systems and functions.

Consider the following criteria when selecting cables that impact safe shutdown equipment:

3.3.1.1.1 The list of cables whose failure could impact the operation of a piece of safe shutdown equipment includes more than those cables connected to the equipment. The relationship between cable and affected equipment is based on a review of the electrical or elementary wiring diagrams. To assure that all cables that could affect the operation of the safe shutdown equipment are identified, investigate the power, control, instrumentation, interlock, and equipment status indication cables related to the equipment. Review additional schematic diagrams to identify additional cables for interlocked circuits that also need to be considered for their impact on the ability of the equipment to operate as required in support of post-fire safe shutdown. As an option, consider applying the screening criteria from Section 3.5 as a part of this section. For an example of this see Section 3.3.1.4.

3.3.1.1.2 In cases where the failure (including spurious operations) of a single cable could impact more than one piece of safe shutdown equipment, associate the cable with each piece of safe shutdown equipment.

3.3.1.1.2.1 Electrical devices such as relays, switches and signal resistor units are considered to be acceptable isolation devices. In the case of instrument loops and electrical metering circuits, review the isolation capabilities of the devices in the loop to determine that an acceptable isolation device has been installed at each point where the loop must be isolated so that a fault would not impact the performance of the safe shutdown instrument function. Refer to Section 3.5 for the types of faults that should be considered when evaluating the acceptability of the isolation device being credited.

3.3.1.1.3 Screen out cables for circuits that do not impact the safe shutdown function of a component (i.e., annunciator circuits, space heater circuits and computer input circuits) unless some reliance on these circuits is necessary. To be properly screened out, however, the circuits associated with these devices must be isolated from the component's control scheme in such a way that a cable fault would not impact the performance of the circuit. Refer to Section 3.5 for the types of faults that should be considered when evaluating the acceptability of the isolation device being credited.

3.3.1.1.4 For each circuit requiring power to perform its safe shutdown function, identify the cable supplying power to each safe shutdown and/or required interlock component. Initially, identify only the power cables from the immediate upstream power source for these interlocked circuits and components (i.e., the closest power supply, load center or motor control center). Review further the electrical distribution system to capture the remaining equipment from the electrical power distribution system necessary to support delivery of power from either the offsite power source or the emergency diesel generators (i.e., onsite power source) to the safe shutdown equipment. Add this equipment to the safe shutdown equipment list. The set of cables described above are classified as required safe shutdown cables. Evaluate the power cables for breaker coordination concerns. The non-safe shutdown cables off of the safe shutdown buses are classified as required for hot shutdown or as important to SSD based on the criteria contained in Appendix H.

3.3.1.1.4.1 The automatic initiation logics for the credited post-fire safe shutdown systems are generally not required to support safe shutdown. Typically, each system can be controlled manually by operator actuation in the main control room or emergency control station. The emergency control station includes those plant locations where control devices, such as switches, are installed for the purpose of operating the equipment. If operator actions to manually manipulate equipment at locations outside the MCR or the emergency control station are necessary, those actions must conform to the regulatory requirements on operator manual actions (See Appendix E). If not protected from the effects of fire, the fire-induced failure of automatic initiation logic circuits should be considered for their potential to adversely affect any post-fire safe shutdown system function.

3.3.1.1.5 Cabling for the electrical distribution system is a concern for those breakers that feed circuits and are not fully coordinated with upstream breakers. With respect to electrical distribution cabling, two types of cable associations exist. For safe shutdown considerations, the direct power feed to a primary safe shutdown component is associated with the primary component and classified as a required safe shutdown cable. For example, the power feed to a pump is necessary to support the pump. Similarly, the power feed from the load center to an MCC supports the MCC. However, for cases where sufficient branch-circuit coordination is not provided, the same cables discussed above would also support the power supply. For example, the power feed to the pump discussed above would support the bus from which it is fed because, for the case of a common power source analysis, the concern is the loss of the upstream power source and not the connected load. Similarly, the cable feeding the MCC from the load center would also be necessary to support the load center. Additionally, the non-safe shutdown circuits off of each of the required safe shutdown components in the electrical distribution system can impact safe shutdown if not properly coordinated. These cables are classified as required for hot shutdown based on the criteria contained in Appendix H.

3.3.1.1.6 Exclusion analysis may be used to demonstrate a lack of potential for any impacts to post-fire safe shutdown from a component or group of components regardless of the cable routing. For these cases, rigorous cable searching and cable to component associations may not be required.

3.3.2 ASSOCIATED ~~CIRCUIT~~CIRCUITCIRCUITS OF CONCERN CABLES

Appendix R, through the guidance provided in NRC Generic Letter 81-12, requires that separation features be provided for associated non-safety circuits that could prevent operation or cause mal-operation due to hot shorts, open circuits, or shorts to ground, of redundant trains of systems necessary to achieve hot shutdown. The three types of associated circuits of concern were identified in Reference 76.1.5 and further clarified in a NRC memorandum dated March 22, 1982 from R. Mattson to D. Eisenhut, Reference 6.7.1.6. They are as follows:

- Spurious actuations
- Common power source
- Common enclosure.

Each of these cables is classified as an associated circuit of concern cable.

Cables Whose Failure May Cause Spurious Operations

Comment [RFR33]: As addressed in RIS 2005-30, only spurious actuations of the type defined in GL 81-12 fall into this category. A spurious actuation that directly prevents the credited redundant safe shutdown train from performing its function is not included in this category of circuits. To put it in more current terms, a spurious actuation affecting a green box component is not an associated circuit of concern, whereas a spurious actuation affecting orange box component could be. The primary distinction being that OMAs can be used to mitigate the latter but not the former according to regulations.

Safe shutdown system spurious operation concerns can result from fire damage to a cable whose failure could cause the spurious operation/mal-operation of equipment whose operation could affect safe shutdown. These cables are identified in Section 3.3.3 together with the remaining safe shutdown cables required to support control and operation of the equipment.

Common Power Source Cables

The concern for the common power source associated circuits of concern is the loss of a safe shutdown power source due to inadequate breaker/fuse coordination. In the case of a fire-induced cable failure on a non-safe shutdown load circuit supplied from the safe shutdown power source, a lack of coordination between the upstream supply breaker/fuse feeding the safe shutdown power source and the load breaker/fuse supplying the non-safe shutdown faulted circuit can result in loss of the safe shutdown bus. This would result in the loss of power to the safe shutdown equipment supplied from that power source preventing the safe shutdown equipment from performing its required safe shutdown function. Identify these cables together with the remaining safe shutdown cables required to support control and operation of the equipment. Refer to Section 3.5.2.4 for an acceptable methodology for analyzing the impact of these cables on post-fire safe shutdown.

Common Enclosure Cables

The concern with common enclosure associated circuits of concern is fire damage to a cable whose failure could propagate to other safe shutdown cables in the same enclosure either because the circuit is not properly protected by an isolation device (breaker/fuse) such that a fire-induced fault could result in ignition along its length, or by the fire propagating along the cable and into an adjacent fire area. This fire spread to an adjacent fire area could impact safe shutdown equipment in that fire area, thereby resulting in a condition that exceeds the criteria and assumptions of this methodology (i.e., multiple fires). Refer to Section 3.5.2.5 for an acceptable methodology for analyzing the impact of these cables on post-fire safe shutdown.

3.3.3 METHODOLOGY FOR CABLE SELECTION AND LOCATION

Refer to Figure 3-4 for a flowchart illustrating the various steps involved in selecting the cables necessary for performing a post-fire safe shutdown analysis.

Comment [RFR34]: What does (*) mean in the table?

Use the following methodology to define the cables required for safe shutdown including cables that may be circuits of concerns for a post-fire safe shutdown analysis. Criteria for making the determination as to which circuits are to be classified as required for hot shutdown or as important to SSD is contained in Appendix H.

3.3.3.1 Identify Circuits Necessary for the Operation of the Safe Shutdown Equipment

For each piece of safe shutdown equipment defined in section 3.2, review the appropriate electrical diagrams including the following documentation to identify the circuits (power, control, instrumentation) required for operation or whose failure may impact the operation of each piece of equipment:

- Single-line electrical diagrams
- Elementary wiring diagrams
- Electrical connection diagrams
- Instrument loop diagrams.

For electrical power distribution equipment such as power supplies, identify any circuits whose failure may cause a coordination concern for the bus under evaluation.

If power is required for the equipment, include the closest upstream power distribution source on the safe shutdown equipment list. Through the iterative process described in Figures 3-2 and 3-3, include the additional upstream power sources up to either the offsite or the emergency power source.

3.3.3.2 Identify Interlocked Circuits and Cables Whose Spurious Operation or Mal-operation Could Affect Shutdown

In reviewing each control circuit, investigate interlocks that may lead to additional circuit schemes, cables and equipment. Assign to the equipment any cables for interlocked circuits that can affect the equipment.

Figure 3-4
Safe Shutdown Cable Selection

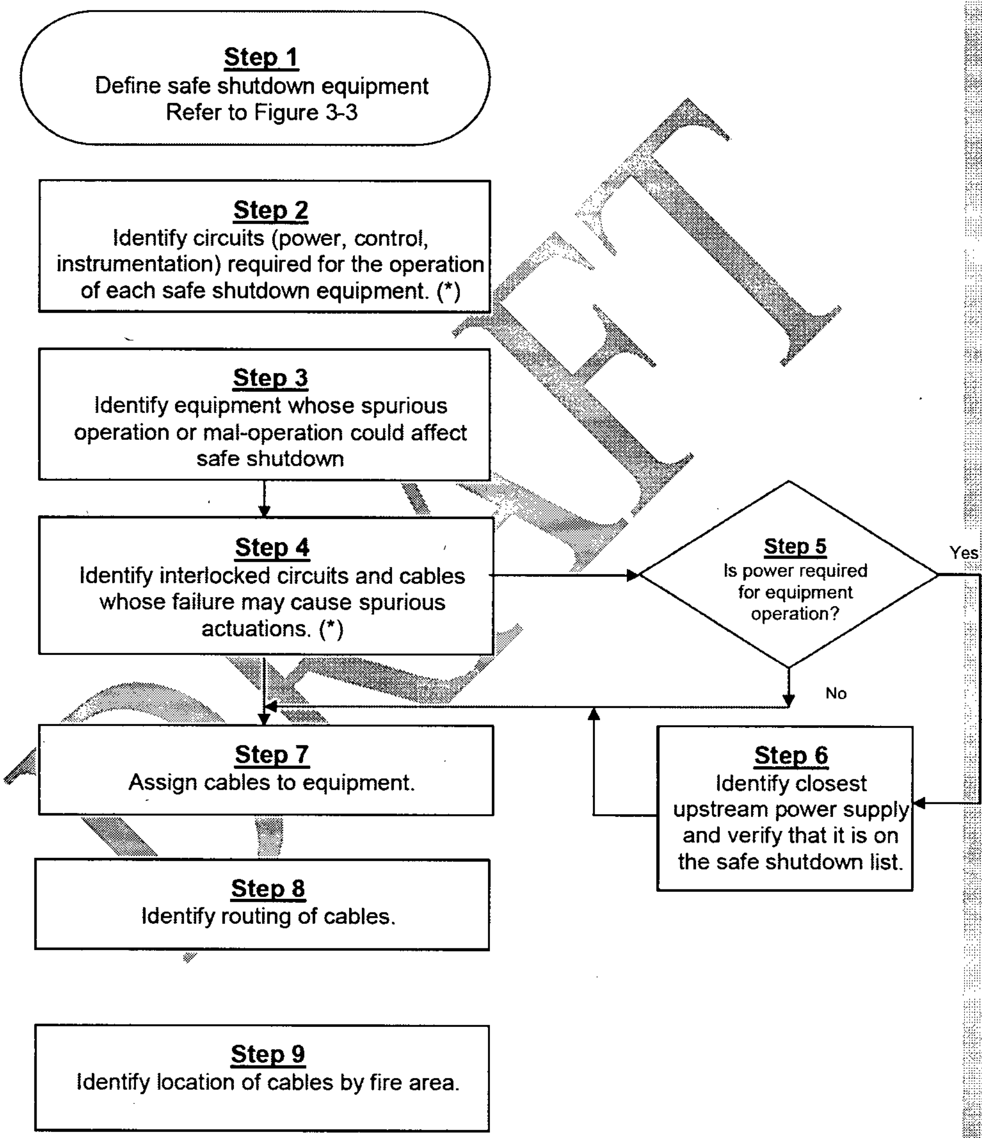
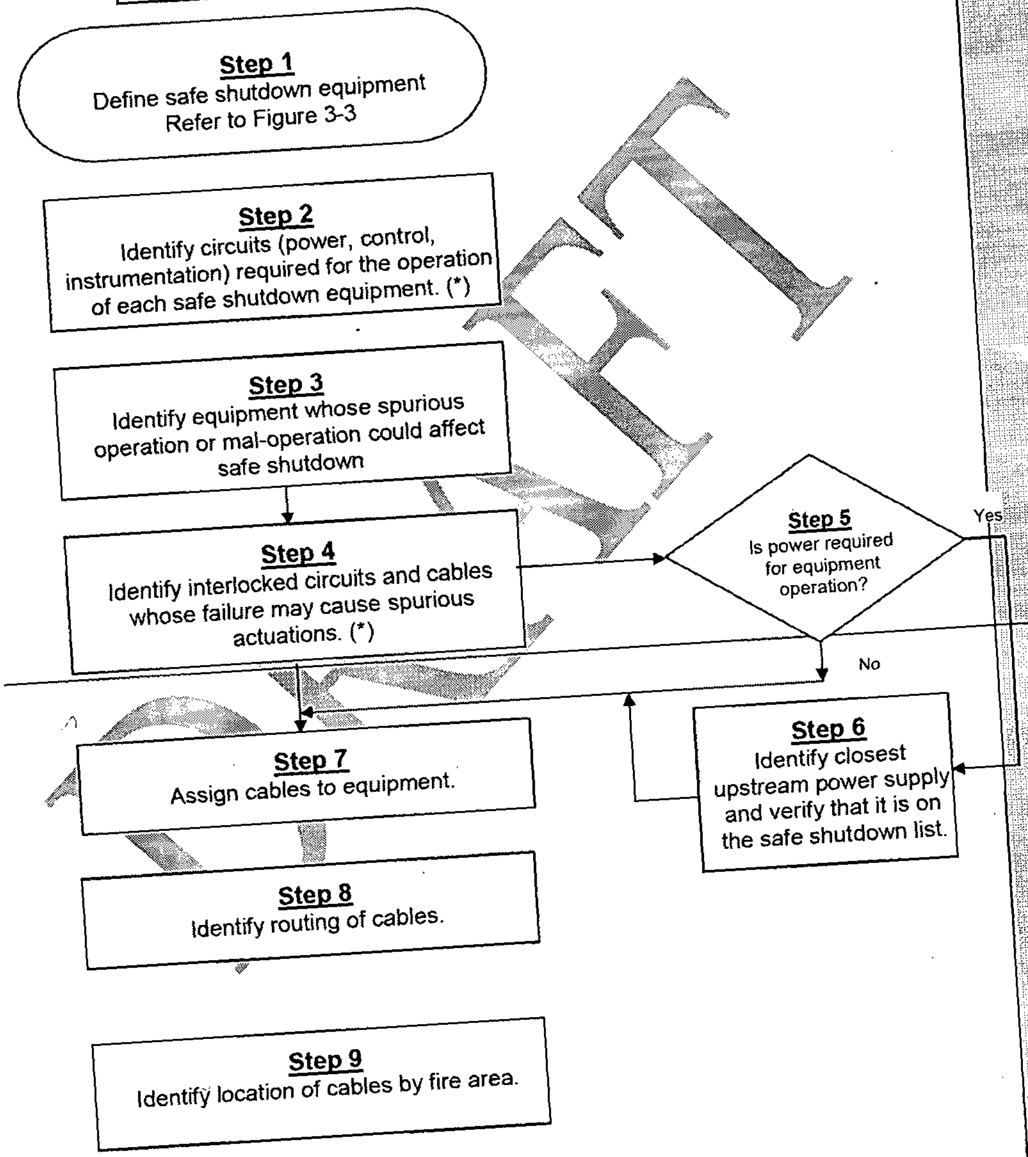


Figure 3-4
Safe Shutdown Cable Selection



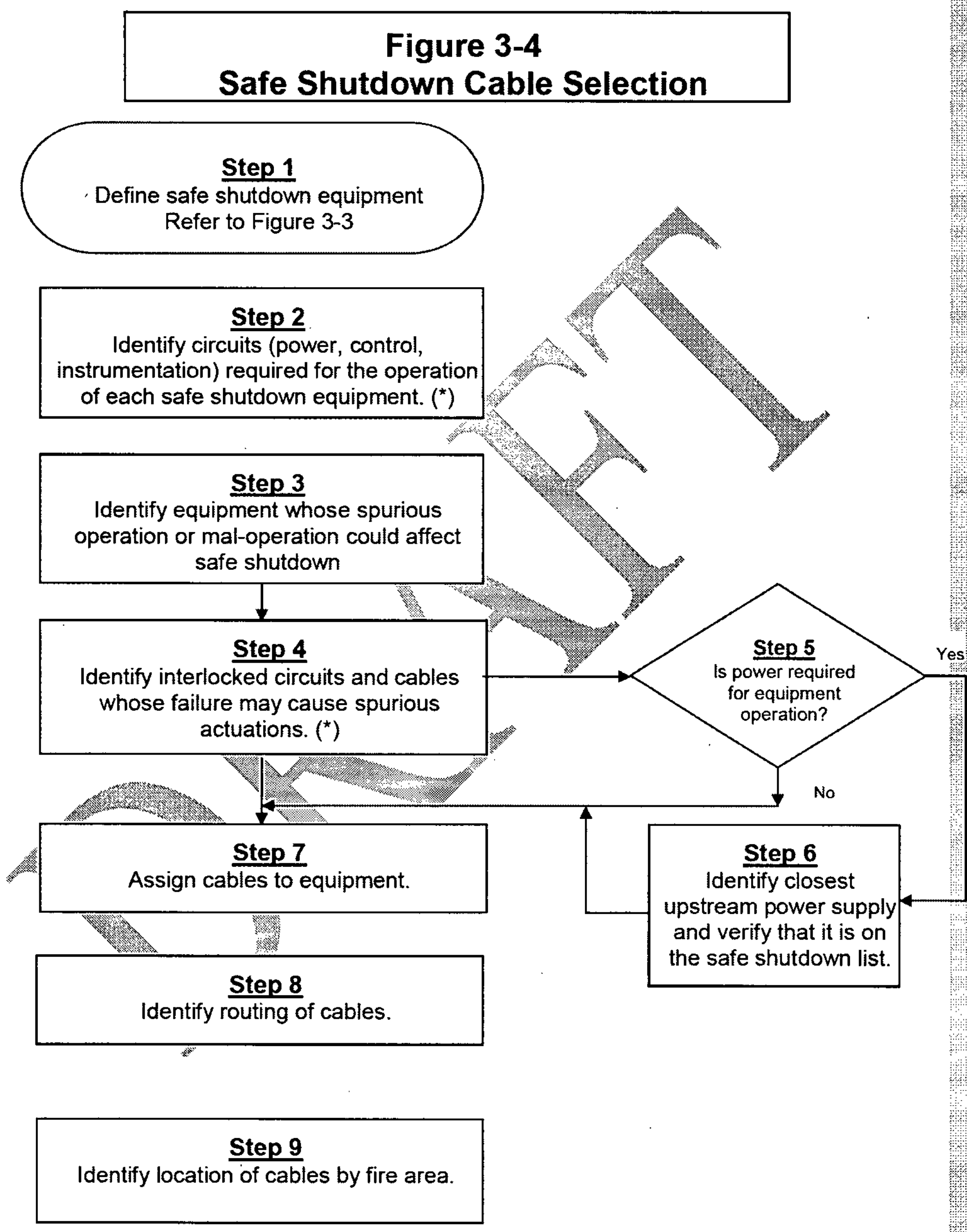


Figure 3-4
Safe Shutdown Cable Selection
Step 1
Define safe shutdown equipment
Refer to Figure 3-3
Step 2
Identify circuits (power, control, instrumentation) required for the operation of each safe shutdown equipment. (*)
Step 3
Identify equipment whose spurious operation or mal-operation could affect safe shutdown
Step 4
Identify interlocked circuits and cables whose failure may cause spurious actuations. (*)
Step 5
Is power required for equipment operation?
Yes
No
Step 6
Identify closest upstream power supply and verify that it is on the safe shutdown list.
Step 7
Assign cables to equipment.
Step 8
Identify routing of cables.
Step 9
Identify location of cables by fire area.

While investigating the interlocked circuits, additional equipment or power sources may be discovered. Include these interlocked equipment or power sources in the safe shutdown equipment list (refer to Figure 3-3) if they can impact the operation of the equipment under consideration in an undesirable manner that impacts post-fire safe shutdown.

3.3.3.3 Assign Cables to the Safe Shutdown Equipment

Given the criteria/assumptions defined in Section 3.3.1, identify the cables required to operate or that may result in mal-operation of each piece of safe shutdown equipment. Cables are classified as either required for hot shutdown or important to SSD based on the classification of the component to which they are associated and the function of that component in supporting post-fire safe shutdown in each particular fire area. Refer to Appendix H for additional guidance.

Tabulate the list of cables potentially affecting each piece of equipment in a relational database including the respective drawing numbers, their revision and any interlocks that are investigated to determine their impact on the operation of the equipment. In certain cases, the same cable may support multiple pieces of equipment. Relate the cables to each piece of equipment, but not necessarily to each supporting secondary component.

If adequate coordination does not exist for a particular circuit, relate the power cable to the power source. This will ensure that the power source is identified as affected equipment in the fire areas where the cable may be damaged. Criteria for making the determination as to which cables are to be classified as required for hot shutdown or as important to SSD is contained in Appendix H.

3.3.3.4 Identify Routing of Cables

Identify the routing for each cable including all raceway and cable endpoints. Typically, this information is obtained from joining the list of safe shutdown cables with an existing cable and raceway database.

3.3.3.5 Identify Location of Raceway and Cables by Fire Area

Identify the fire area location of each raceway and cable endpoint identified in the previous step and join this information with the cable routing data. In addition, identify the location of field-routed cable by fire area. This produces a database containing all of the cables requiring fire area analysis, their locations by fire area, and their raceway.

Comment [RFR35]: A raceway or cable end points may be in more than one fire area. Guidance should address how to track these in database.

3.4 FIRE AREA ASSESSMENT AND COMPLIANCE STRATEGIES

By determining the location of each component and cable by fire area and using the cable to equipment relationships described above, the affected safe shutdown equipment in each fire area can be determined. Using the list of affected equipment in each fire area, the impacts to safe shutdown systems, paths and functions can be determined. Based on an assessment of the number and types of these impacts, the required safe shutdown path for each fire area can be determined. The specific impacts to the selected safe shutdown path can be evaluated using the circuit analysis and evaluation criteria contained in Section 3.5 of this document. Knowing which components and systems are performing which safe shutdown functions, the required and important to SSD components can be classified. Once these component classifications have been made the tools available for mitigating the affects of fire induced damage can be selected. Refer to Appendix H for additional guidance on classifying components as either required for hot shutdown or important to safe shutdown. For MSOs the Resolution Methodology outlined in Section 4, Section 5, Appendix B and Appendix G should be applied. Components in each MSO are classified as either required for hot shutdown or important to safe shutdown components using the criteria from Appendix H. Similarly, this classification determines the available tools for mitigating the affects of fire-induced damage to the circuits for these components.

Having identified all impacts to the required safe shutdown path in a particular fire area, this section provides guidance on the techniques available for individually mitigating the effects of each of the potential impacts.

3.4.1 CRITERIA/ASSUMPTIONS

The following criteria and assumptions apply when performing "deterministic" fire area compliance assessment to mitigate the consequences of the circuit failures identified in the previous sections for the required safe shutdown path in each fire area.

3.4.1.1 Assume only one fire in any single fire area at a time.

3.4.1.2 Assume that the fire may affect all unprotected cables and equipment within the fire area. This assumes that neither the fire size nor the fire intensity is known. This is conservative and bounds the exposure fire that is postulated in the regulation.

3.4.1.3 Address all cable and equipment impacts affecting the required safe shutdown path in the fire area. All potential impacts within the fire area must be addressed. The focus of this section is to determine and assess the potential impacts to the required safe shutdown path selected for achieving post-fire safe shutdown and to assure that the required safe shutdown path for a given fire area is properly protected.

3.4.1.4 Use the criteria from Appendix H to classify each impacted cable/component as either a required or important to SSD cable/component.

3.4.1.5 Use operator manual actions where appropriate, for cable/component impacts classified as important to SSD cable/components, to achieve and maintain post-fire safe shutdown conditions in accordance with NRC requirements (refer to Appendix E). For additional criteria to be used when determining whether an operator manual action may be used for a flow diversion off of the primary flow path, refer to Appendix H.

3.4.1.6 Where appropriate to achieve and maintain cold shutdown within 72 hours, use repairs to equipment required in support of post-fire shutdown.

3.4.1.7 For the components on the required safe shutdown path classified as required hot shutdown components as defined in Appendix H, Appendix R compliance requires that 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 (III.G.1.a). When cables or equipment are within the same fire area outside primary containment and separation does not already exist, provide one of the following means of separation for the required safe shutdown components impacted circuit(s):

- Separation of cables and equipment and associated nonsafety circuits of redundant trains within the same fire area by a fire barrier having a 3-hour rating (III.G.2.a)
- Separation of cables and equipment and associated nonsafety circuits of redundant trains within the same fire area 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 (III.G.2.b).
- Enclosure of cable and equipment and associated non-safety circuits of one redundant train within a fire area in a fire barrier having a one-hour rating. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area (III.G.2.c).

For fire areas inside non-inerted containments, the following additional options are also available:

- Separation of cables and equipment and associated nonsafety circuits of redundant trains by a horizontal distance of more than 20 feet with no intervening combustibles or fire hazards (III.G.2.d);
- Installation of fire detectors and an automatic fire suppression system in the fire area (III.G.2.e); or
- Separation of cables and equipment and associated non-safety circuits of redundant trains by a noncombustible radiant energy shield (III.G.2.f).

Use exemptions, deviations, LARs and licensing change processes to satisfy the requirements mentioned above and to demonstrate equivalency depending upon the plant's license requirements.

3.4.1.8 Consider selecting other equipment that can perform the same safe shutdown function as the impacted equipment. In addressing this situation, each equipment impact, including spurious operation, is to be addressed in accordance with regulatory requirements and the NPP's current licensing basis. With respect to MSOs, the criteria in Chapter 4, Appendix B, Appendix G and Appendix H should be used.

3.4.1.9 Consider the effects of the fire on the density of the fluid in instrument tubing and any subsequent effects on instrument readings or signals associated with the protected safe shutdown path in evaluating post-fire safe shutdown capability. This can be done systematically or via procedures such as Emergency Operating Procedures.

3.4.2 METHODOLOGY FOR FIRE AREA ASSESSMENT

Refer to Figure 3-5 for a flowchart illustrating the various steps involved in performing a fire area assessment.

Use the following methodology to assess the impact to safe shutdown and demonstrate Appendix R compliance:

3.4.2.1 Identify the Affected Equipment by Fire Area

Identify the safe shutdown cables, equipment and systems located in each fire area that may be potentially damaged by the fire. Provide this information in a report format. The report may be sorted by fire area and by system in order to understand the impact to each safe shutdown path within each fire area (see Attachment 5 for an example of an Affected Equipment Report).

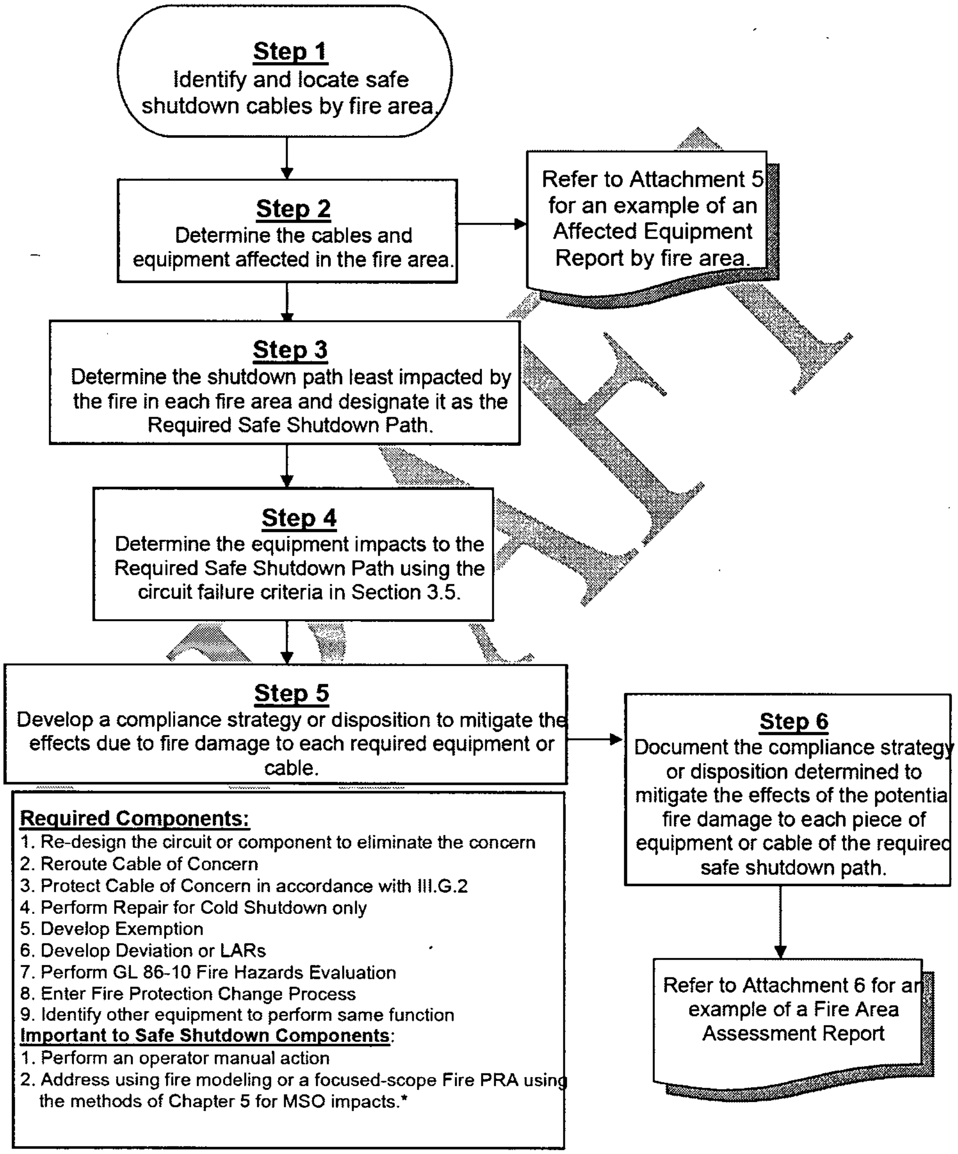
3.4.2.2 Determine the Shutdown Paths Least Impacted By a Fire in Each Fire Area

Based on a review of the systems, equipment and cables within each fire area, determine which shutdown paths are either unaffected or least impacted by a postulated fire within the fire area. Typically, the safe shutdown path with the least number of cables and equipment in the fire area would be selected as the required safe shutdown path. Consider the circuit failure criteria and the possible mitigating strategies, however, in selecting the required safe shutdown path in a particular fire area. Review support systems as a part of this assessment since their availability will be important to the ability to achieve and maintain safe shutdown. For example, impacts to the electric power distribution system for a particular safe shutdown path could present a major impediment to using a particular path for safe shutdown. By identifying this early in the assessment process, an unnecessary amount of time is not spent assessing impacts to the frontline systems that will require this power to support their operation. Determine which components are required hot shutdown components and which components are important to SSD components using the guidance in Appendix H.

Based on an assessment as described above, designate the required safe shutdown path(s) for the fire area. Classify the components on the required safe shutdown path necessary to perform the required safe shutdown functions as required safe shutdown components. Identify all equipment not in the safe shutdown path whose spurious operation or mal-operation could affect the shutdown function. Criteria for classifying these components as required for hot shutdown or as important to SSD is contained in Appendix H. Include the affected cables in the shutdown function list. For each of the safe shutdown cables (located in the fire area) that are part of the required safe shutdown path in the fire area, perform an evaluation to determine the impact of a fire-induced cable failure on the corresponding safe shutdown equipment and, ultimately, on the required safe shutdown path.

When evaluating the safe shutdown mode for a particular piece of equipment, it is important to consider the equipment's position for the specific safe shutdown scenario for the full duration of the shutdown scenario. It is possible for a piece of equipment to be in two different states depending on the shutdown scenario or the stage of shutdown within a particular shutdown scenario. Document information related to the normal and shutdown positions of equipment on the safe shutdown equipment list.

Figure 3-5
Fire Area Assessment Flowchart



* Seek regulatory approval where necessary

3.4.2.3 Determine Safe Shutdown Equipment Impacts

Using the circuit analysis and evaluation criteria contained in Section 3.5 of this document, determine the equipment that can impact safe shutdown and that can potentially be impacted by a fire in the fire area, and what those possible impacts are.

3.4.2.4 Develop a Compliance Strategy or Disposition to Mitigate the Effects Due to Fire Damage to Each Required Component or Cable

The available deterministic methods for mitigating the effects of circuit failures are summarized as follows (see Figure 1-1):

Required Safe Shutdown Components:

- Re-design the circuit or component to eliminate the concern. This option will require a revision to the post-fire safe shutdown analysis.
- Re-route the cable of concern. This option will require a revision to the post-fire safe shutdown analysis.
- Protect the cable in accordance with III.G.2.
- Provide a qualified 3-fire rated barrier.
- Provide a 1-hour fire rated barrier with automatic suppression and detection.
- Provide separation of 20 feet or greater with automatic suppression and detection and demonstrate that there are no intervening combustibles within the 20 foot separation distance.
- Perform a cold shutdown repair in accordance with regulatory requirements.
- Identify other equipment not affected by the fire capable of performing the same safe shutdown function.
- Develop exemptions, deviations, LARs, Generic Letter 86-10 evaluation or fire protection design change evaluations with a licensing change process.

Important to Safe Shutdown Components:

- Any of the options provided for required for hot shutdown components.
- Perform and operator manual action in accordance with Appendix E.
- Address using fire modeling or a focused-scope fire PRA using the methods of Chapter 5 for MSO impacts.

Additional options are available for non-inerted containments as described in 10 CFR 50 Appendix R section III.G.2.d, e and f.

3.4.2.5 Document the Compliance Strategy or Disposition Determined to Mitigate the Effects Due to Fire Damage to Each Required Component or Cable

Assign compliance strategy statements or codes to components or cables to identify the justification or mitigating actions proposed for achieving safe shutdown. The justification should address the cumulative effect of the actions relied upon by the licensee to mitigate a fire in the area. Provide each piece of safe shutdown equipment, equipment not in the path whose spurious operation or mal-operation could affect safe shutdown, and/or cable for the required safe shutdown path with a specific compliance strategy or disposition. Refer to Attachment 6 for an example of a Fire Area Assessment Report documenting each cable disposition.

3.5 CIRCUIT ANALYSIS AND EVALUATION

This section on circuit analysis provides information on the potential impact of fire on circuits used to monitor, control and power safe shutdown equipment. Applying the circuit analysis criteria will lead to an understanding of how fire damage to the cables may affect the ability to achieve and maintain post-fire safe shutdown in a particular fire area. This section should be used in conjunction with Section 3.4, to evaluate the potential fire-induced impacts that require mitigation. When assessing fire-induced damage to that could potentially result in MSOs, the circuit failure criteria in Appendix B should be used. For all non-MSO fire-induced circuit failure impacts, the criteria in this section apply.

Comment [RFR36]: Does this mean that this section applies to single spurious actuations? The applicability of this section should be to all circuits required for safe shutdown.

Appendix R Section III.G.2 identifies the fire-induced circuit failure types that are to be evaluated for impact from exposure fires on safe shutdown equipment. Section III.G.2 of Appendix R requires consideration of hot shorts, shorts-to-ground and open circuits.

3.5.1 CRITERIA/ASSUMPTIONS

Apply the following criteria/assumptions when performing fire-induced circuit failure evaluations.

3.5.1.1 Consider the following circuit failure types on each conductor of each unprotected safe shutdown cable to determine the potential impact of a fire on the safe shutdown equipment associated with that conductor.

- A hot short may result from a fire-induced insulation breakdown between conductors of the same cable, a different cable or from some other external source resulting in a compatible but undesired impressed voltage or signal on a specific conductor. A hot short may cause a spurious operation of safe shutdown equipment.
- An open circuit may result from a fire-induced break in a conductor resulting in the loss of circuit continuity. An open circuit may prevent the ability to control or power the affected equipment. An open circuit may also result in a change of state for normally energized equipment. (e.g. [for BWRs] loss of power to the Main Steam Isolation Valve (MSIV) solenoid valves due to an open circuit will result in the closure of the MSIVs).

- A short-to-ground may result from a fire-induced breakdown of a cable insulation system, resulting in the potential on the conductor being applied to ground potential. A short-to-ground may have all of the same effects as an open circuit and, in addition, a short-to-ground may also cause an impact to the control circuit or power train of which it is a part.

Consider the three types of circuit failures identified above to occur individually on each conductor of each safe shutdown cable on the required safe shutdown path in the fire area.

There is one specific exception to the criteria described above where the evaluation of multiple hot shorts on separate conductors in a single multi-conductor cable are be evaluated.

The exception is the double dc break solenoid circuit design discussed in the NRC Memo from Gary Holahan, Deputy Director Division of Systems Technology, dated December 4, 1990 and filed contained under ML062300013. [Reference Figure B.3.3(f) of NFPA 805 – 2001.]

There is also one specific example of where multiple shorts-to-ground should be considered for their impact on the integrity of an ungrounded circuit. This exception is discussed in Figure 3.5.2-3.

These exceptions are a stand alone exceptions that does not imply the need to expand the circuit failure criteria applied in a deterministic analysis beyond these specific cases. Should similar examples arise, however, these examples should be brought to the attention of the NEI CF – ITF for their consideration in including additional exceptions in future revisions to NEI 00-01.

Comment [RFR37]: If there are multiple components with unprotected cables in the same fire area that are required to operate for safe shutdown, they must all be assumed to fail simultaneously. That's not MSO. This statement implies that they would be evaluated as separate failures.

Comment [h38]: These exceptions should not be applied to this approach since they attempt to limit the consideration of multiple fire impacts.

For the plant Specific List of MSOs use the circuit failure criteria outlined in Appendix B.

3.5.1.2 Assume that circuit contacts are initially positioned (i.e., open or closed) consistent with the normal mode/position of the safe shutdown equipment as shown on the schematic drawings. The analyst must consider the position of the safe shutdown equipment for each specific shutdown scenario when determining the impact that fire damage to a particular circuit may have on the operation of the safe shutdown equipment.

3.5.1.3 Assume that circuit failure types resulting in spurious operations exist until action has been taken to isolate the given circuit from the fire area, or other actions have been taken to negate the effects of circuit failure that is causing the spurious operation. The fire is not assumed to eventually clear the circuit fault. For MSOs involving AC circuits, the criteria in Appendix B of hot shorts clearing and going to ground within 20 minutes may be used with the risk-informed approach using the Limited Scope Fire PRA.

3.5.1.4 When both trains are in the same fire area outside of primary containment, all cables that do not meet the separation requirements of Section III.G.2 are assumed to fail in their worst case configuration.

Comment [d39]: PQ: GL 86-10 Question 5.3.2 Hot Short Duration, states "We would postulate that a "hot short" condition exists until action has been taken to isolate the given circuit from the fire area, or other actions as appropriate have been taken to negate the effects of the spurious actuation. We do not postulate that the fire would eventually clear the "hot short." The NEI guidance appears to be based on the extremely limited testing done to date. Limited data is acceptable for the NFPA 805 risk based program. It is not acceptable for compliance with deterministic compliance. The 20 minutes should not be endorsed for deterministic analysis

3.5.2 TYPES OF CIRCUIT FAILURES

Appendix R requires that nuclear power plants must be designed to prevent exposure fires from defeating the ability to achieve and maintain post-fire safe shutdown. Fire damage to circuits that provide control and power to equipment on the required safe shutdown path and any other equipment whose spurious operation/mal-operation could affect shutdown in each fire area must be evaluated for the effects of a fire in that fire area. Only one fire at a time is assumed to occur. The extent of fire damage is assumed to be limited by the boundaries of the fire area. Given this set of conditions, it must be assured that one redundant train of equipment necessary to achieve and maintain hot shutdown is free of fire damage for fires in every plant location. To provide this assurance, Appendix R requires that equipment and circuits required for hot shutdown be free of fire damage and that these circuits be designed for the fire-induced effects of a hot short, short-to-ground, or an open circuit. With respect to the electrical distribution system, the issue of breaker coordination must also be addressed. Criteria for making the determination as to which breakers are are to be classified as required for hot shutdown is contained in Appendix H.

This section will discuss specific examples of each of the following types of circuit failures:

- Open circuit
- Short-to-ground
- Hot short.

Also, refer to Appendix B for the circuit failure criteria to be applied in assessing the impact of the Plant Specific List of MSOs on post-fire safe shutdown.

3.5.2.1 Circuit Failures Due to an Open Circuit

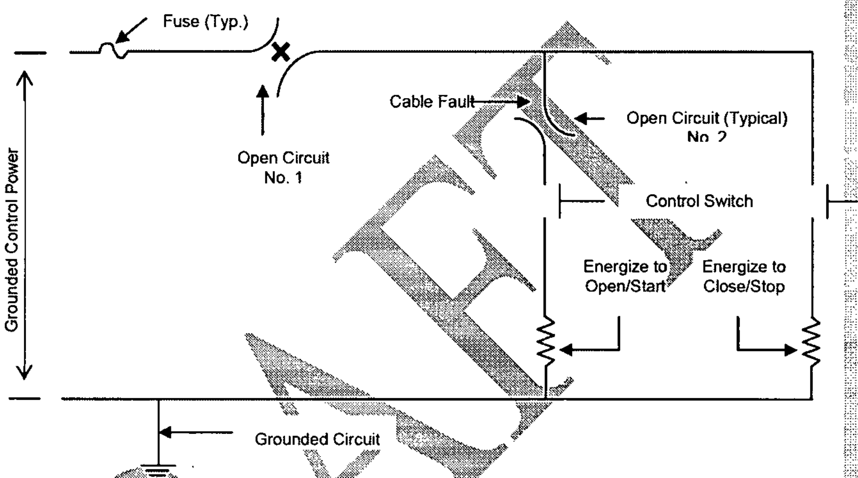
This section provides guidance for addressing the effects of an open circuit for safe shutdown equipment. An open circuit is a fire-induced break in a conductor resulting in the loss of circuit continuity. An open circuit will typically prevent the ability to control or power the affected equipment. An open circuit can also result in a change of state for normally energized equipment. For example, a loss of power to the main steam isolation valve (MSIV) solenoid valves [for BWRs] due to an open circuit will result in the closure of the MSIV.

- Loss of electrical continuity may occur within a conductor resulting in de-energizing the circuit and causing a loss of power to, or control of, the required safe shutdown equipment.
- In selected cases, a loss of electrical continuity may result in loss of power to an interlocked relay or other device. This loss of power may change the state of the equipment. Evaluate this to determine if equipment fails safe.

- Open circuit on a high voltage (e.g., 4.16 kV) ammeter current transformer (CT) circuit may result in secondary damage, possibly resulting in the occurrence of an additional fire in the location of the CT itself.

Figure 3.5.2-1 shows an open circuit on a grounded control circuit.

Figure 3.5.2-1
Open Circuit
(Grounded Control Circuit)



Open circuit No. 1:

An open circuit at location No. 1 will prevent operation of the subject equipment.

Open circuit No. 2:

An open circuit at location No. 2 will prevent opening/starting of the subject equipment, but will not impact the ability to close/stop the equipment.

3.5.2.2 Circuit Failures Due to a Short-to-Ground

This section provides guidance for addressing the effects of a short-to-ground on circuits for safe shutdown equipment. A short-to-ground is a fire-induced breakdown of a cable insulation system resulting in the potential on the conductor being applied to ground potential. A short-to-ground can cause a loss of power to or control of required safe shutdown equipment. In addition, a short-to-ground may affect other equipment in the electrical power distribution system in the cases where proper coordination does not exist.

There is no limit to the number of shorts to ground caused by the fire.

Consider the following consequences in the post-fire safe shutdown analysis when determining the effects of circuit failures related to shorts-to-ground:

- A short to ground in a power or a control circuit may result in tripping one or more isolation devices (i.e. breaker/fuse) and causing a loss of power to or control of required safe shutdown equipment.
- In the case of certain energized equipment such as HVAC dampers, a loss of control power may result in loss of power to an interlocked relay or other device that may cause one or more spurious operations.

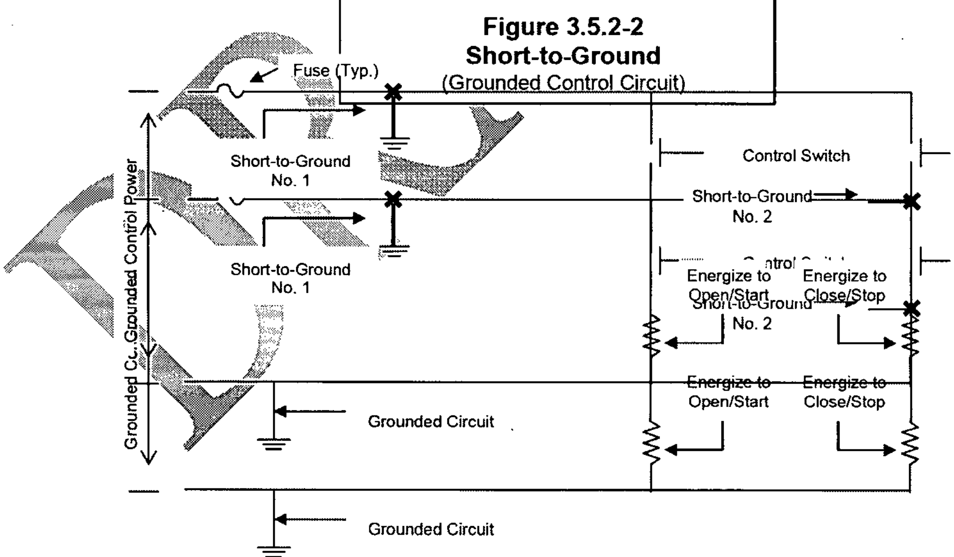
Short-to-Ground on Grounded Circuits

Typically, in the case of a grounded circuit, a short-to-ground on any part of the circuit would present a concern for tripping the circuit isolation device thereby causing a loss of control power.

Figure 3.5.2-2 illustrates how a short-to-ground fault may impact a grounded circuit.

Figure 3.5.2-2
Short-to-Ground
(Grounded Control Circuit)

Figure 3.5.2-2
Short-to-Ground
(Grounded Control Circuit)



Short-to-ground No. 1:

A short-to-ground at location No. 1 will result in the control power fuse blowing and a loss of power to the control circuit. This will result an inability to operate the equipment using the control switch. Depending on the coordination characteristics between the protective device on this circuit and upstream circuits, the power supply to other circuits could be affected.

Short-to-ground No. 2:

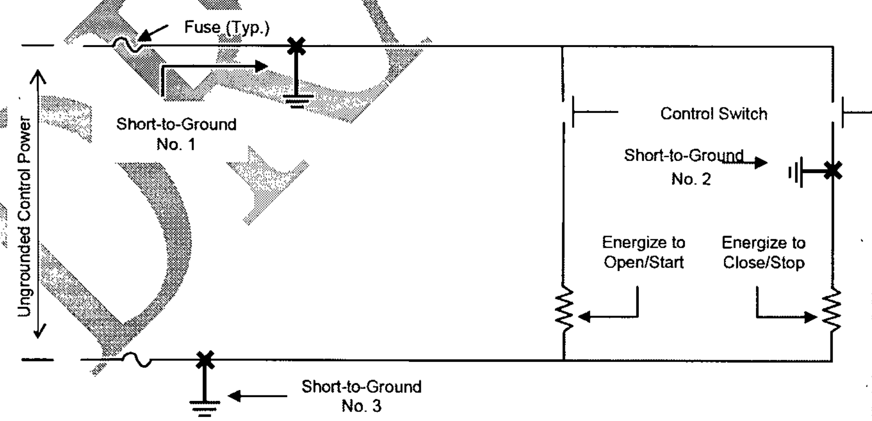
A short-to-ground at location No. 2 will have no effect on the circuit until the close/stop control switch is closed. Should this occur, the effect would be identical to that for the short-to-ground at location No. 1 described above. Should the open/start control switch be closed prior to closing the close/stop control switch, the equipment will still be able to be opened/started.

Short-to-Ground on Ungrounded Circuits

In the case of an ungrounded circuit, postulating only a single short-to-ground on any part of the circuit may not result in tripping the circuit isolation device. Another short-to-ground on the circuit or another circuit from the same source would need to exist to cause a loss of control power to the circuit.

Figure 3.5.2-3 illustrates how a short to ground fault may impact an ungrounded circuit.

Figure 3.5.2-3
Short-to-Ground
(Ungrounded Control Circuit)



Short-to-ground No. 1:

A short-to-ground at location No. 1 will result in the control power fuse blowing and a loss of power to the control circuit if short-to-ground No. 3 also exists either within the same circuit or on any other circuit fed from the same power source. This will result in an inability to operate the equipment using the control switch. Depending on the coordination characteristics between the protective device on this circuit and upstream circuits, the power supply to other circuits could be affected. If multiple grounds can occur in a single fire area, they should be assumed to occur simultaneously unless justification to the contrary is provided.

Short-to-ground No. 2:

A short-to-ground at location No. 2 will have no effect on the circuit until the close/stop control switch is closed. Should this occur, the effect would be identical to that for the short-to-ground at location No. 1 described above. Should the open/start control switch be closed prior to closing the close/stop control switch, the equipment will still be able to be opened/started. If multiple grounds can occur in a single fire area, they should be assumed to occur simultaneously unless justification to the contrary is provided.

Comment [h40]: This discussion may not be correct unless the order and specific pairs of shorts to ground that occur are specified. If No. 1 and No. 2 occur simultaneously, it results in a spurious actuation.

3.5.2.3 Circuit Failures Due to a Hot Short

This section provides guidance for analyzing the effects of a hot short on circuits for required safe shutdown equipment. A hot short is defined as a fire-induced insulation breakdown between conductors of the same cable, a different cable or some other external source resulting in an undesired impressed voltage on a specific conductor. The potential effect of the undesired impressed voltage would be to cause equipment to operate or fail to operate in an undesired manner.

Consider the following specific circuit failures related to hot shorts as part of the post-fire safe shutdown analysis:

- A hot short between an energized conductor and a de-energized conductor within the same cable may cause a spurious operation of equipment. The spuriously operated device (e.g., relay) may be interlocked with another circuit that causes the spurious operation of other equipment. This type of hot short is called an intra-cable hot short (also known as conductor-to-conductor hot short or an internal hot short).

- A hot short between any external energized source such as an energized conductor from another cable and a de-energized conductor may also cause a spurious operation of equipment. This is called an inter-cable hot short (also known as cable-to-cable hot short/external hot short).

A Hot Short on Grounded Circuits

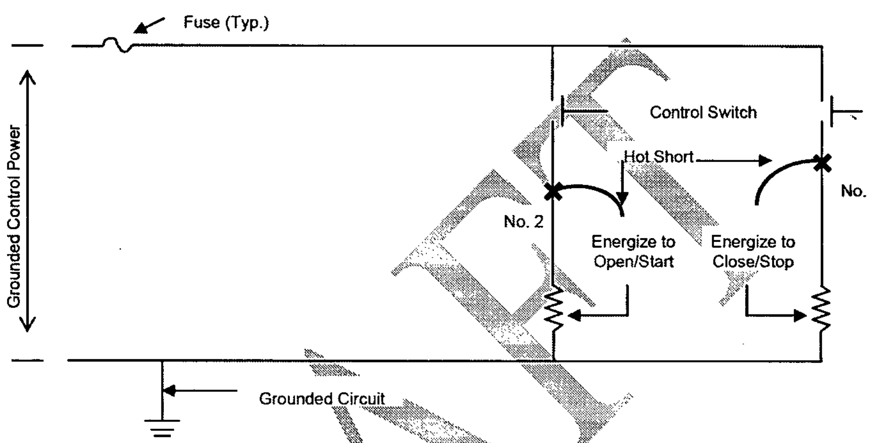
A short-to-ground is another failure mode for a grounded control circuit. A short-to-ground as described above would result in de-energizing the circuit. This would further reduce the likelihood for the circuit to change the state of the equipment either from a control switch or due to a hot short. Nevertheless, a hot short still needs to be considered. Figure 3.5.2-4 shows a typical grounded control circuit that might be used for a motor-operated valve. However, the protective devices and position indication lights that would normally be included in the control circuit for a motor-operated valve have been omitted, since these devices are not required to understand the concepts being explained in this section. In the discussion provided below, it is assumed that a single fire in a given fire area could cause any one of the hot shorts depicted.

Comment [h41]: There is a need to explain in this document the issues and analysis techniques on how to address IN 92-18 for MOVs.

The following discussion describes how to address the impact of these individual cable faults on the operation of the equipment controlled by this circuit.

Comment [RFR42]: "how to address" implies the way to mitigate the fault.

Figure 3.5.2-4
Hot Short
(Grounded Control Circuit)



<u>Hot short No. 1</u>:

A hot short at this location would energize the close relay and result in the undesired closure of a motor-operated valve.

<u>Hot short No. 2</u>:

A hot short at this location would energize the open relay and result in the undesired opening of a motor-operated valve.

<u>A Hot Short on Ungrounded Circuits</u>

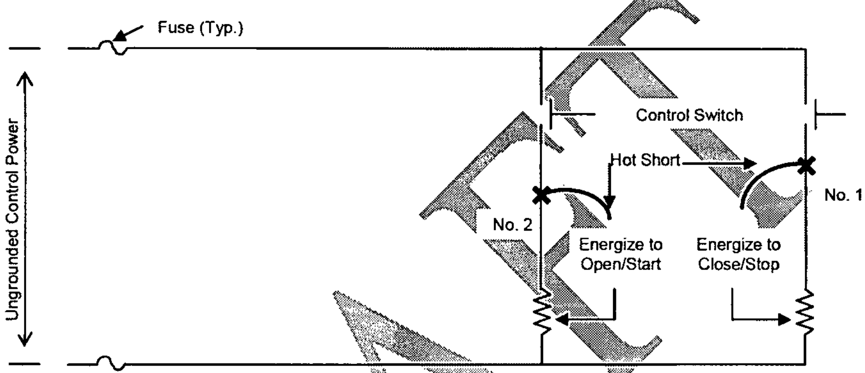
In the case of an ungrounded circuit, a single hot short may be sufficient to cause a spurious operation. A single hot short can cause a spurious operation if the hot short comes from a circuit from the positive leg of the same ungrounded source as the affected circuit.

In reviewing each of these cases, the common denominator is that in every case, the conductor in the circuit between the control switch and the start/stop coil must be involved.

Figure 3.5.2-5 depicted below shows a typical ungrounded control circuit that might be used for a motor-operated valve. However, the protective devices and position indication lights that would normally be included in the control circuit for a motor-operated valve have been omitted, since these devices are not required to understand the concepts being explained in this section.

In the discussion provided below, it is assumed that a single fire in a given fire area could cause any one of the hot shorts depicted. The discussion provided below describes how to address the impact of these cable faults on the operation of the equipment controlled by this circuit.

Figure 3.5.2-5
Hot Short
(Ungrounded Control Circuit)



Hot short No. 1:

A hot short at this location from the same control power source would energize the close relay and result in the undesired closure of a motor operated valve.

Hot short No. 2:

A hot short at this location from the same control power source would energize the open relay and result in the undesired opening of a motor operated valve.

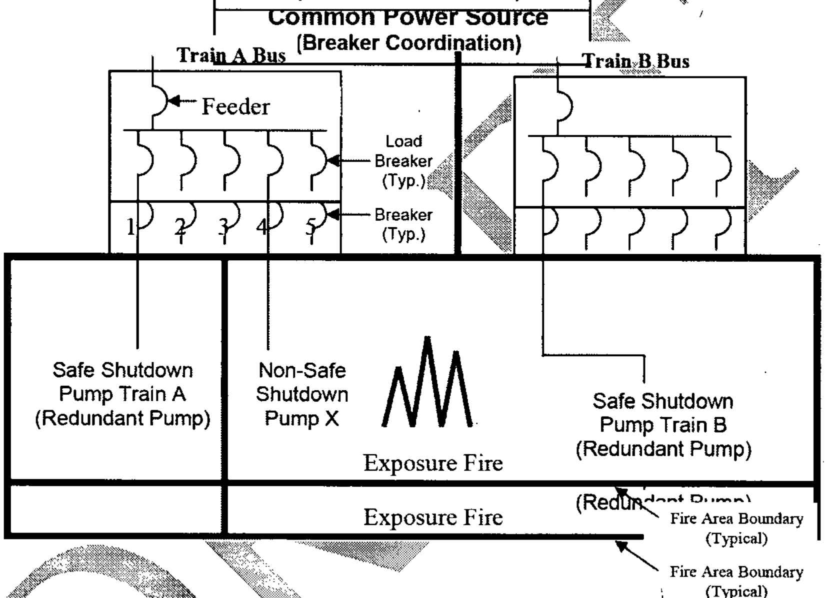
3.5.2.4 Circuit Failures Due to Inadequate Circuit Coordination

The evaluation of circuits of a common power source consists of verifying proper coordination between the supply breaker/fuse and the load breakers/fuses for power sources that are required for hot shutdown. The concern is that, for fire damage to a single power cable, lack of coordination between the supply breaker/fuse and the load breakers/fuses can result in the loss of power to a safe shutdown power source that is required to provide power to safe shutdown equipment.

For the example shown in Figure 3.5.2-6, the circuit powered from load breaker 4 supplies power to a non-safe shutdown pump. This circuit is damaged by fire in the same fire area as the circuit providing power to from the Train B bus to the Train B pump, which is redundant to the Train A pump.

To assure safe shutdown for a fire in this fire area, the damage to the non-safe shutdown pump powered from load breaker 4 of the Train A bus cannot impact the availability of the Train A pump, which is redundant to the Train B pump. To assure that there is no impact to this Train A pump due to the circuits' common power source breaker coordination issue, load breaker 4 must be fully coordinated with the feeder breaker to the Train A bus.

Figure 3.5.2-6
Common Power Source
(Breaker Coordination)



A coordination study should demonstrate the coordination status for each required common power source. For coordination to exist, the time-current curves for the breakers, fuses and/or protective relaying must demonstrate that a fault on the load circuits is isolated before tripping the upstream breaker that supplies the bus. Furthermore, the available short circuit current on the load circuit must be considered to ensure that coordination is demonstrated at the maximum fault level.

The methodology for identifying potential circuits of a common power source and evaluating circuit coordination cases on a single circuit fault basis is as follows:

- Identify the power sources required to supply power to safe shutdown equipment.
- For each power source, identify the breaker/fuse ratings, types, trip settings and coordination characteristics for the incoming source breaker supplying the bus and the breakers/fuses feeding the loads supplied by the bus.

- For each power source, demonstrate proper circuit coordination using acceptable industry methods.

Comment [h43]: Are "acceptable industry methods" clear enough to provide proper guidance on how to address potential fire damage to cables?

- For power sources not properly coordinated, tabulate by fire area the routing of cables whose breaker/fuse is not properly coordinated with the supply breaker/fuse. Evaluate the potential for disabling power to the bus in each of the fire areas in which the circuit of concern are routed and the power source is required for hot shutdown. Prepare a list of the following information for each fire area:

  - Cables of concern.
  - Affected common power source and its path.
  - Raceway in which the cable is enclosed.
  - Sequence of the raceway in the cable route.
  - Fire zone/area in which the raceway is located.

  For fire zones/areas in which the power source is disabled, the effects are mitigated by appropriate methods.

- Develop analyzed safe shutdown circuit dispositions for the circuit of concern cables routed in an area of the same path as required by the power source. Evaluate adequate separation and other mitigation measures based upon the criteria in Appendix R, NRC staff guidance, and plant licensing bases.

3.5.2.5 Circuit Failures Due to Common Enclosure Concerns

The common enclosure concern deals with the possibility of causing secondary failures due to fire damage to a circuit either whose isolation device fails to isolate the cable fault or protect the faulted cable from reaching its ignition temperature, or the fire somehow propagates along the cable into adjoining fire areas.

The electrical circuit design for most plants provides proper circuit protection in the form of circuit breakers, fuses and other devices that are designed to isolate cable faults before ignition temperature is reached. Adequate electrical circuit protection and cable sizing are included as part of the original plant electrical design maintained as part of the design change process. Proper protection can be verified by review of as-built drawings and change documentation. Review the fire rated barrier and penetration designs that preclude the propagation of fire from one fire area to the next to demonstrate that adequate measures are in place to alleviate fire propagation concerns.

4 IDENTIFICATION AND TREATMENT OF MULTIPLE SPURIOUS OPERATIONS USING RISK-INFORMED METHODS

4.1 INTRODUCTION

The purpose of this section is to provide a methodology for addressing multiple fire- induced circuit failures and multiple spurious operations (MSOs) by individual licensees. This methodology uses identification and analysis techniques similar to methods applied under NEI 04-02 for Risk-Informed Fire Protection, but do not include steps for self-issued change analysis as allowed under NEI 04-02 and NFPA-805. MSOs identified during this process will include both required for hot shutdown and important to SSD circuit components, with different mitigation strategies for each type of MSO as shown on Figure 3-1 above.

With NRC acceptance, the methodology presented in this document addresses multiple spurious operations resulting from fire-induced circuit failures for safe shutdown in accordance with 10 CFR 50 Appendix R, Sections III.G.1 and III.G.2.

The basic philosophy behind this method is that the Fire Safe Shutdown Procedures and associated Operator Actions should focus on potentially risk important scenarios. This agrees with the philosophy as described in RIS 2004-03, which was developed for inspection criteria. Application of the deterministic criteria in Chapter 3 of this document to multiple spurious operations would require all potential fire-induced spurious operations to be identified and a mitigating action to be developed for each. This mitigating action may be an action taken prior to the start of the fire event that precludes the condition from occurring or as a post fire action that mitigates the effects of the condition prior to it reaching an unrecoverable condition relative to safe shutdown. The corresponding mitigating action for each potential spurious operation must be known and this action must be capable of limiting the potential adverse affects of the spurious operation without reliance on any other equipment that is also potentially susceptible to a spurious operation resulting from a fire in the same fire area.

Comment [h44]: Although RIS 2004-03 is risk informed, it was developed to provide inspection guidance, not for use in performing design basis determinations.

If the procedures and actions were expanded to include very low risk scenarios, the operator actions would become too complex, resulting in higher expected operator failures for the important scenarios. Additionally, if the required timing for actions were to consider all low risk scenarios, the resulting procedural actions would likely be modified to include actions that can raise the overall plant risk, such as implementing a Self-Induced Station Blackout. Mitigation might also require significant modification to plant safety-related systems and logics that could have the undesired consequence of reducing their reliability in mitigating the affects of other events, thereby causing an overall increase in plant risk. By placing bounds on the number of scenarios that the procedures address, this results in lower plant risk by ensuring optimal operator response for the potential risk important scenarios.

This philosophy is similar to the development of plant emergency operating procedures, where low risk scenarios are not included in the procedures while potentially high-risk scenarios and "Design Basis" scenarios are addressed.

If a mitigating action is not taken for multiple spurious operations identified using the methods described below, a regulatory submittal (Exemption/Deviation) must be developed. In order to minimize the number of regulatory submittals, the method provided must limit the multiple spurious operations to be consistent with RIS 2004-03 by concentrating identification on circuit failures that have a relatively high likelihood of occurrence.

Additionally, the methodology must provide a process for incorporating new information on spurious operations that are determined to be likely to occur. This may include new information gained from additional fire testing, or as a result of feedback from plants implementing this method (or NFPA 805).

The list of Generic Multiple Spurious Operations developed by the Owner's Groups and required to be considered in conjunction with the information in this appendix are contained in Appendix G. The Generic MSO lists include both required for hot shutdown and important to SSD component MSO combinations. Many MSOs on the list is are identified as either required for hot shutdown or important to SSD, based on generic review of each MSO. The generic classification provided in Appendix G for each MSO should be confirmed by each licensee depending on the safe shutdown methodology used in each of their fire areas. Analysis or further review of the MSOs not initially classified as either required for hot shutdown or important to safe shutdown component MSO combinations is required, based on the guidance discussed in Appendix H. The types of circuit failures and the number of these types of circuit failures that are to be considered in each circuit type when evaluating the impact of an MSO on post-fire safe shutdown are described in Appendix B.

Appendix B is used to address multiple spurious operations (both required for hot shutdown and important to SSD MSOs). The affects of single spurious operations due to single fire induced circuit failure is to be addressed using the methods in Chapter 3 of this document.

The process described below, including the generic MSO lists, do not artificially limit the number of spurious operations or hot shorts included in each scenario considered. In some cases, spurious operation of a specific component may require multiple hot shorts. Depending on the type of circuit involved, guidance on the appropriate assumptions to be made relative to this condition is contained in Appendix B. It is also intended that if multiple hot shorts are required to cause the MSO, this should not result in any screening of MSOs from consideration prior to the inclusion of the MSO combination in the Safe Shutdown analysis. The multiple hot shorts would be considered when reviewing the hot shorts against the cable criteria in Appendix B or in the PRA calculations.

4.2 OVERVIEW OF THE MSO IDENTIFICATION AND TREATMENT PROCESS

Figure 4-1 provides an overview of the MSO Identification and Treatment Process. Sections 4.3 to 4.5 below provide a description of each of the steps in the figure.

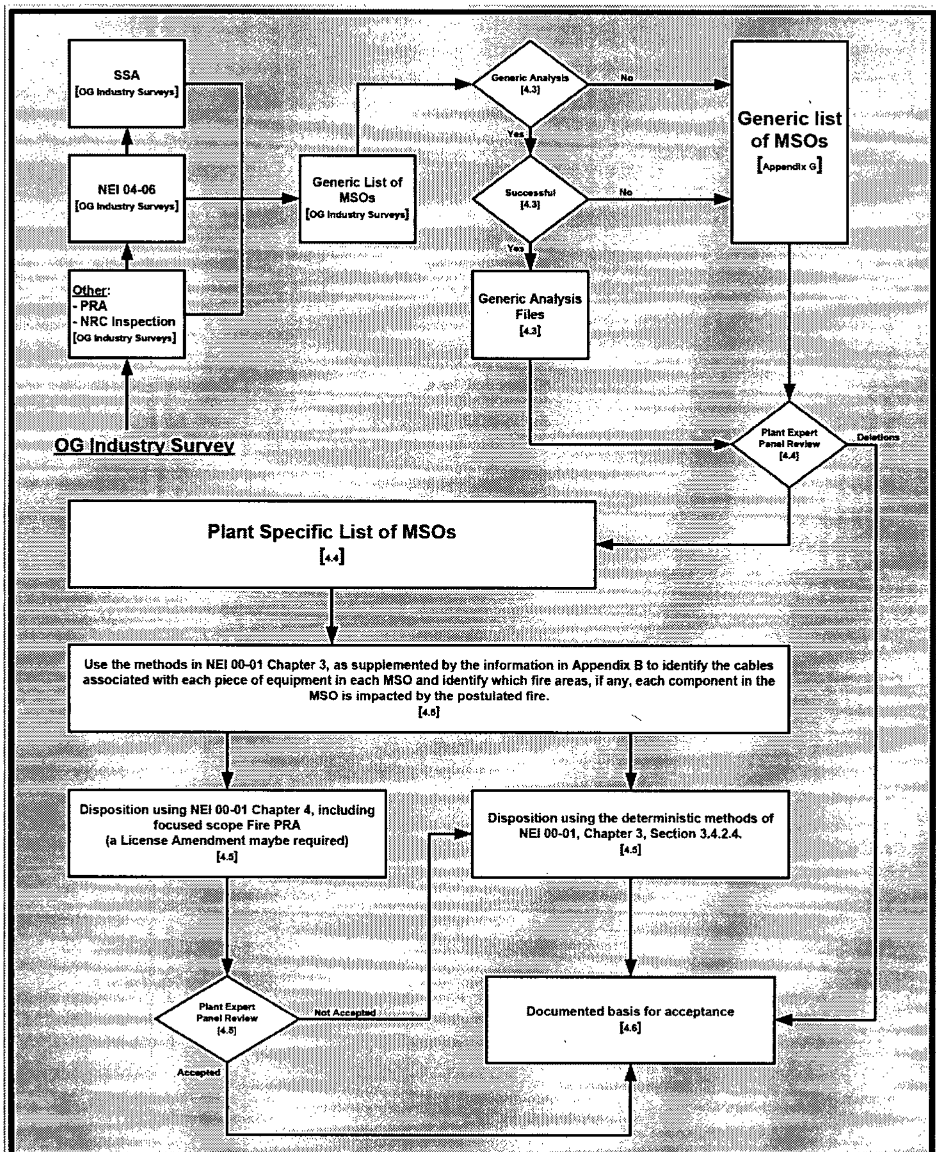


Figure 4.1 - Resolution Methodology

Comment [h45]: Figure changed to require LAR for focused scope Fire PRA.

4.3 GENERIC LIST OF MSOS

Appendix G provides a list of generic scenarios to consider in a plant specific evaluation for multiple spurious. The generic list of MSOs was developed from an industry survey of all US plants. The survey asked the plants to "Describe the extent to which multiple hot shorts and multiple spurious operations (MSOs) have been addressed for your facility in each of the following areas:"

1) Licensing Basis Safe Shutdown Analysis

2) Assessments performed for NRC RIS 2004-03 using NEI 04-06

3) Evaluations performed as a result of NRC Inspections

4) MSO Expert Panel Reviews conducted for Fire PRA or NFPA 805

5) Other Instances where MSOs [Combined Equipment Impacts] with potential risk significance been identified (e.g. PRA Analysis Internal Events Model, Fire PRA or other source)

The results of the survey responses were then compiled into a table, and the final list is a composite list of applicable scenarios for each reactor type.

Although not all scenarios for a reactor type are considered applicable to every reactor, the list is provided here as an input to the MSO identification and treatment process.

The generic MSO list in Appendix G includes a classification of each MSO as either requiring a plant specific analysis, required for hot shutdown or important to SSD component MSO. The "Rrequiring A Plant Specific Analysis"~~requiring a plant specific analysis~~ classification is used where the classification could be either required for hot shutdown or important to SSD depending on its use in an individual fire area. MSOs for required circuit components are addressed differently than MSOs for important to SSD components, with the use Operator Manual Actions, Fire Modeling or Focused-scope FPRA not generically authorized by the NRC to be applied to MSOs categorized as required for hot shutdown component MSOs. Exemptions, deviations or LARs, depending on a licensee's current licensing basis, maywill be required to use operator manual actions, fire modeling or focused-scope fire PRAs for required for hot shutdown MSOs. The "gGeneric"~~generic~~ or "Requiring A Plant Specific Analysis"~~requiring a plant specific analysis~~ classifications provided in Appendix G for each MSO should be confirmed by licensees depending on the safe shutdown methodology used in each of their fire areas. .

As can be seen from Figure 4-1, generic Owner's Group analysis can be performed for a given reactor type to disposition generic MSO scenarios. The generically dispositioned scenarios do not need to be included in the plant specific MSO list, provided an individual licensee performs a review of the generic analysis, verifies plant specific parameters bound those critical parameters used in the generic analysis and obtain the concurrence of its plant specific Expert Panel. The method and the critical parameters used for each generic analysis will vary, depending on the

MSO. These aspects of the generic analysis are not described further in this document. Refer to each generic analysis for the required information.

4.4 PLANT SPECIFIC LIST OF MSOS

The method described below provides steps to provide a more accurate and complete list of MSO to be addressed in the plants SSA. This includes steps that both a) screen the generic list of MSO scenarios that are not applicable to a plant and b) add new scenarios that are not listed in the generic scenarios. The generic classification provided in Appendix G for each MSO should be confirmed by each licensee depending on the safe shutdown methodology used in each of their fire areas. Additionally, any new MSOs that are identified are reviewed to determine if the MSO involves required for hot shutdown or important to SSD components.

4.4.1 SCREENING (DELETION) OF GENERIC MSO SCENARIOS

The screening of generic MSO scenarios can be performed to remove from consideration scenarios not applicable for a given plant. The screening process involves the review of each scenario in the generic list for applicability and disposition. Scenarios can be screened from the plant specific MSO list, given the following:

1) Components identified in the scenario do not exist in the plant, and the scenario is not applicable to similar components or systems, or

2) Specific plant design features (see additional comments below) make the scenario either not possible, or does not fail the safe shutdown function.

Some of the scenarios that are listed in Appendix G are described as being applicable to a specific vintage of plant design. For example, most of the scenarios listed for BWR 2's, might be assumed to have no applicability to BWR 3's or 4's. This may be the case for the particular scenario listed. Item 1 above, however, requires that each licensee look at the scenarios provided and examine them for similar components or systems used in the design of the plant under evaluation. Conversely, even when the scenario is listed for a particular design vintage of plants, such as the BWR 2's, a scenarios related to isolation condensers would only be applicable to BWR 2's that have isolation condensers. The considerations described above need to be employed in each licensee's plant specific evaluation of MSOs.

Additionally, scenarios screened from the plant specific MSO list should be reviewed with the following considerations:

A) If the design feature that makes the scenario not possible for the plant involves cable routing, circuit design, electrical protection, or other similar design feature, the scenario should not be screened from consideration at this step. Similarly, if an operator action is in place that would prevent the scenario, the scenario should not be screened at this step. The process for these scenarios would be to include the scenario in the MSO list, and to use the design feature as a disposition for the MSO.

B) Documentation that the scenario does not fail the safe shutdown function should be based on the original Safe Shutdown Analysis assumptions. If specific analysis is performed to show the MSO doesn't fail the function, then the MSO should be included in the plant specific MSO list, and the analysis used in the disposition of the MSO.

C) If a generic analysis is available for an MSO, the generic analysis should be reviewed to verify that the analysis is applicable to the plant being reviewed and that no plant unique features invalidate the inputs, assumptions, methodology, results or conclusions of the generic analysis. The expert panel should review the MSO in conjunction with the generic analysis and, if acceptable, disposition the MSO for the plant under review without additional consideration in the plant unique analysis. The MSO, the generic analysis used to disposition the MSO and any additional considerations should be documented in the expert panel report and in the licensee's safe shutdown analysis.

For item A) above, the general concept is that if the design feature can possibly change as a result of a design change, the MSO needs to be included in the site specific MSO list. This would ensure that changes to the design would be reviewed against the MSO to ensure the MSO remains not possible as changes are made to the plant over the course of time. For item B) it is intended that whatever is credited in the original SSA, this is carried forward to the MSO list. For example, if there are two injection trains credited for all "A" train fire areas, and an MSO fails only one of the two trains, then the MSO can be screened at this point. In this example, however, the post-fire safe shutdown analysis must be revised to make it clear that only a single injection train is credited in all "A" train fire areas. Another example would be a scenario that drains a water supply tank into the containment sump, and analysis is performed to show the water can be provided from the sump to an injection pump. In this example, if the sump flow path was not in the original SSA, the MSO should not be screened.

Deletions from the Generic List of MSOs are subject to review and concurrence by the Expert Panel. One alternative to the initial screening of generic MSOs is to perform the screening during the expert panel process. This can be done simultaneous to the expert panel exploration of new MSO scenarios,. either plant specific or similar to the screened MSO. Documentation of screened MSOs would be required, with performed with the initial screening or by the expert panel.

Comment [h46]: Is this part of the sentence needed?

4.4.2 PLANT SPECIFIC ADDITIONS TO MSO LIST

An Expert Panel Review of the MSO list determines plant Specific Additions. The additions can come from a number of sources, including:

1) MSOs resulting from review of the existing Safe Shutdown Analysis
2) MSOs resulting from review of the PRA sensitivity runs or results
3) MSOs identified by the Expert Panel
4) Required Hot Shutdown System Full Flow Divergent Paths, as defined within the Plant's specific IST Program.

The first two inputs are as a result of preparatory work for the Expert Panel review. These preparatory steps and the performance of the Expert Panel process are described in the following sections. Plant specific additions include both required for hot shutdown and important to SSD component MSOs.

4.4.2.1 Review of Existing Safe Shutdown Analysis

As an input to the Expert Panel process, a list of the existing SSA spurious operations components and scenarios should be developed. Much of the information for this list is already available in SSA supporting documents, but may not be in a form to support external review or an expert panel. This list should provide both a description of the scenario of concern and the disposition of the scenario in the SSA. Operator Manual Actions associated with any disposition should also be documented, including documentation of feasibility criteria (timing, etc.). Key to the documentation are any assumptions made for the SSA, since these assumptions may not be valid for multiple spurious operations scenarios. Both generic and scenario specific assumptions should be documented as an input to the expert panel review.

Scenarios that are dispositioned as not needing operator manual action (or other compliance strategies), due to the presence of additional components down stream of the initial component, should be reviewed by the expert panel in detail. Pre-identification of these scenarios as additions to the MSO list should be performed. For example, if a diversion includes two MOVs, and the first MOV is dispositioned as not a concern due to the presence of the second MOV, then the expert panel should consider spurious operation of both MOVs as a potential multiple spurious operation scenario. Similarly, if a non-post-fire safe shutdown credited pump start is not a concern due to a closed discharge MOV/AOV, then the expert panel should consider the scenario (Pump spuriously starts and valve spuriously opens).

Similarly, for a post-fire safe shutdown credited pump start with a normally open minimum flow valve, then the expert panel should consider the scenario (Pump spuriously starts and the minimum flow valve spuriously closes).

Scenarios where positive operator manual action is taken where both single and multiple spurious operations are addressed may need to be considered further. The scenario would need to be reviewed for the effect on timing and operator action feasibility to ensure no further review is required. For example, if operator action on a flow path is determined to have 20 minutes prior to reaching an unrecoverable state, but a second spurious can change the timing to 10 minutes, then a review by the expert panel is needed. This timing issue is especially critical for spurious pump operation. For example, for PWR SG overfeed or for the pressurizer going solid, the timing for single pump spurious start/run can be much different that when two or three pumps start/run, and the credited operator manual action may not be completed in time for the MSO.

An Example SSA Results Table is provided in Table 1 below. Notice that in the table, there are several examples where Expert Panel Consideration will be required. For example, for MOV-1, the expert panel will need to consider the timing to see if additional spurious operations will result in failure of the feasibility criteria. For MOV-2, the credited disposition is the use of another valve, MOV-3. If the same fire can damage this MOV-3, then a multiple spurious scenario may result. MOV-4 is likely to not be a concern for multiple spurious scenarios, unless it can be involved in scenarios involving hot standby. In this case, it could affect the timing of an existing scenario or result in a new scenario being introduced.

Table 1 (example)
Existing SSA Spurious Operations Components and Scenarios

Component	Scenario	Disposition	Reference for Disposition
MOV-1	Spurious Opening Results in Excess Letdown	Local Operator Manual Action per procedure OP-3	Manual Actions Feasibility
MOV-2	Spurious Closure results in a loss of injection	Use of second injection valve, MOV-3	Procedure OP-3, step 17
MOV-4	Spurious Closure will result in failure of letdown. This will result in the inability to achieve cold shutdown in 72 hours	Manual Action per procedure OP-3	Manual Actions Feasibility

Comment [h47]: Should it be a procedure number here - OP-3? Should an additional column be added for "Feasibility?"

4.4.2.2 PRA Input to the Plant Specific MSO List

A review of PRA results should be performed in preparation for the expert panel review. If this PRA review was provided as a part of the development of the generic MSO list, this step may not be necessary, depending on the completeness of the information provided for the generic MSO list, and whether item 3 below (new accident sequence review) was performed as input to the generic MSO list.

PRA input to the Expert Panel Review (below) can include a number of inputs, depending on the status and completeness of the PRA and Fire PRA effort. Appendix F includes a broad discussion of PRA reviews that can be performed, including the following:

1) Cutset, or Sequence or Risk Importance Measure Review – a review of cutsets sorted by probability or order to indicate where fire-induced damage can result in a potentially high-risk sequence. Cutsets can also be manipulated by setting basic events representing fire-induced spurious operation (e.g., fail to remain open or closed) to 1.0 and resort the cutsets. This review should result in an identification of spurious operation failure modes (fail to remain opened or closed) with a high Risk Achievement Worth or F-V importance.

2) Resolve the model, by assuming a fire-induced initiating event has occurred (Reactor Trip, Loss of Offsite Power) and spurious operation events are set to 1.0, including (but not limited to):
   - MOV spuriously open or close
   - AOV spuriously open or close
   - PORV spuriously open or close
   - Spurious actuation of automatic actuation signals

3) Review of possible new Fire-Induced Accident Sequences. This would include a review similar to that performed in preparation for a Fire PRA model development, where fire damage or the performance of operator actions following a fire are assumed, and any accident sequences not already included in the PRA are identified. Details of this review are provided in Attachment H.

The above PRA reviews do not include a complete list of sensitivity studies or analysis that can be performed using an existing PRA. In addition, a simple review of risk importance measures, especially Risk Achievement Worth (RAW) of spurious operations, would be useful.

For Event tree linking models, Fussel-Vesely and Risk Achievement Worth of individual basic events representing spurious actuations can be calculated in a similar manner to that performed for fault tree linking models. However the process of identifying potentially risk significant multiple spurious actuations is slightly more involved with a linked event tree model due to the lack of sequence cutsets. In this case the spurious actuation basic events are set to 1.0 and the sequences (combinations of split fractions leading to core damage) are resolved. The new set of dominant sequences should then be compared with those derived from the base case quantification to identify those sequences that have risen significantly in value. This is followed by an investigation of the cutsets associated with those split fractions which contribute to the inflated sequence values to identify spurious and multiple spurious actuation combinations.

If a full Fire PRA is available, then the results of the Fire PRA can be used as a direct input to the Expert Panel Review (or directly to the Safe Shutdown Analysis, if expert panel review is determined to be not needed for important scenarios). In this case, the following should be included in the safe shutdown analysis:

1) Components whose spurious operation in combination with other components results in a risk for the combination (including all cutsets for all fire areas/scenarios) that is above the criteria in Section 5.4.2.

2) Single spurious operations, where direct core damage would occur when fire-induced damage of other components in the scenario occurs, and post-fire operator action is assumed failed.

Comment [h48]: It is still an MSO since it involves the single and other actuations that are being considered assuming a failed OMA?

The output from any PRA review should be assessed and summarized. The results of this assessment will be provided to the expert panel for additional considerations.

4.4.2.3 Expert Panel Identification of MSO New Scenarios

The Expert Panel Review is performed to systematically and completely review all spurious and MSO scenarios and determine whether or not each individual scenario is to be included or excluded from the plant specific list of multiple spurious operations to be considered in the plant specific post-fire safe shutdown analysis. Input to the Expert Panel is provided from a number of sources discussed above, resulting in a comprehensive review of spurious operation scenarios.

NEI 04-06, Appendix A provides the scope of circuits to be reviewed, including specific examples of circuit combinations to be included in a review. For example, A-2.1.2.2.1 includes specific PWR examples to be reviewed. These examples should be reviewed in detail by the expert panel to determine scenarios to be reviewed further.

Prior to performing the expert panel review, the following is performed in preparation:

1) Provide to the expert panel, the results of the SSA and PRA performed above.
2) Provide to the expert panel the generic MSO list and any plant specific review of this list.
3) Provide training to the expert panel.

If the expert panel is held over a several day period, and substitute expert panel members are used, substitute members should also be provided the above information and training prior to participating.

The expert panel as used for the review of MSOs, results in a list of potential MSO that supplements the previously screened generic MSO list. Scenarios identified by the expert panel that should be considered in the SSA are documented and added to the generic MSO list for disposition using the process described in 4.5 below.

As discussed in Appendix F, complete documentation of the expert panel review for new MSOs is important. This documentation should include details of the new MSOs to be considered, as well as possible MSO scenarios that were not considered for treatment under the SSA and the reasoning for not recommending them for consideration. See appendix F for further discussion on documentation of the process, training and results.

4.4.3 Expert Panel Review of MSO List Deletions

The MSO Expert Panel will review all recommended deletions of the generic MSO list. In this review, the expert panel will perform the following functions:

1) Review the justification for deletion. Ensure the justification follows the guidance above in 4.4.1, and the justification is adequate.

2) Discuss the possible addition of alternate and similar MSO scenarios applicable for the plant.

The expert panel review of the deletions should be documented in a report and retained in support of the MSO review process. Refer to Appendix F for additional guidance on the Expert Panel review.

4.5 ADDRESSING THE PLANT SPECIFIC LIST OF MSOS

4.5.1 CABLE SELECTION & ASSOCIATION FOR EACH COMPONENT IN AN MSO

Components that are not already included in the base SSA are added to the Safe Shutdown Equipment list and analyzed in the same manner as other components in that list. The approach outlined in Section 3.3 can be used to determine the cables associated with each component in an MSO combination. Cables are associated with MSO components in the same manner as they are associated with any other safe shutdown component. In some cases, only those cables with the potential to spuriously operate the component need to be added to the SSA.

4.5.2 DETERMINATION OF MSO CATEGORIZATION

Prior to performing the Fire Area Assessment and developing the compliance strategy for the MSOs, each MSO must be reviewed to determine if it involves required for hot shutdown components. The criteria for determining whether a component is a required for hot shutdown or important to SSD component is contained in Appendix H. Each MSO on the plant specific MSO list is reviewed against the criteria in Appendix H and categorized as either a required component MSO or an important to SSD component MSO in each affected fire area, depending on the manner in which safe shutdown is achieve in each fire area.

Each MSO that is derived from the Generic MSO list is provided a preliminary classification. This classification, however, needs to reviewed and verified on a plant specific basis. Additionally, a classification needs to be developed for the plant specific MSO additions.

4.5.3 FIRE AREA ASSESSMENT AND COMPLIANCE STRATEGIES FOR MSOS

Impacts to specific MSOs are assessed on a fire area basis in the same manner as other impacts to post-fire safe shutdown components. Each component in an MSO combination is assigned to a safe shutdown path. If the individual safe shutdown component's safe shutdown path association is different than the safe shutdown path associated with the component when assessed as part of an MSO, then the additional safe shutdown path(s) associated with the MSO must also be assigned to each component in that MSO. If all components associated with a particular safe shutdown path are located in a common fire area where they have the potential, if damaged by a fire, to impact the required safe shutdown path for that fire area, then a mitigating strategy must be provided for the MSO.

Comment [h49]: Is this step necessary? It would appear that if the MSOs are addressed based on risk significance, it doesn't matter what path they are associated with.

Mitigation strategies applicable to MSOs include the following in addition to the traditional mitigation strategies described in Section 3.4.2.4 for required for hot shutdown components:

1) Disposition based on consideration of Circuit Failure Criteria.
2) Disposition based on Fire Modeling
3) Disposition based on a Focused-Scope Fire PRA

Mitigation strategy 2 and 3 are not generically authorized by the NRC for use with required for hot shutdown component MSOs. Exemptions, deviations or LARs, depending on a licensee's current licensing basis, may beare required to use mitigation strategies 2 and 3 for required for hot shutdown MSOs.

Several considerations may affect the disposition method chosen for an MSO. First, the least expensive method for dispositioning an MSO may be the traditional compliance strategy, such as a design change or use of an approved operator manual action. If the PRA or Fire Modeling analysis takes more resources to perform than fixing the design or adding a simple operator manual action, then cost may dictate the approach used. If an approved operator manual action is used, however, consideration of the effect of this operator manual action on other fire response operator manual actions should be considered. For example, if the addition of a new operator manual action means the fire response procedure is more difficult, then the existing actions may become less reliable. In this case, the addition of the operator manual action may increase overall risk rather than reducing risk as intended.

This balance is to be considered prior to selecting a mitigating strategy that relies upon operator manual action.

4.5.3.1 Mitigation through Consideration of Circuit Failure Criteria

Circuit failure criteria applicable to MSOs is contained in Appendix B. When evaluating the impact of an MSO on a particular fire area, the circuit failure types for the circuit types contained in Appendix B should be considered. Using the circuit failure criteria, MSOs should be considered as potential "combined equipment impacts". Stated differently, if any of the fire induced circuit failures ~~failure~~ as described in Appendix B can cause an impact to the group of components in the MSO, this must be evaluated. For example, if the listed MSO were the failure of the block valve to close in conjunction with a spurious opening of a PORV, the block valve would need to be evaluated for circuit failure types that could prevent closure of the block valve, (i.e. a short-to-ground causing a loss of control power or an open circuit causing a loss of circuit continuity). Similarly, if an immediate operator manual action to close the block valve at the start of the fire were credited and, if a hot short could subsequently spuriously open the block valve in the same fire area where another hot short could cause the spurious opening of the PORV, then this condition also needs to be addressed.

If all potential fire-induced circuit failures outlined in Appendix B are addressed and, if none leads to all components in the MSO being damaged in a manner that impacts the required post-fire safe shutdown path, then the MSO is dispositioned on the basis of circuit analysis.

If mitigation by the use of circuit analysis is not possible, then another means of mitigation, either one of the traditional means described in Section 3.4.2.4 or one of the means listed below, must be developed. If either of the means listed below is used as the mitigating strategy for the MSO, then review and acceptance of the disposition by the Expert Panel is required.

4.5.3.2 Fire Modeling Disposition

Licensees currently perform qualitative fire ignition, fire spread and fire damage analysis as a part of fire hazard analyses, engineering equivalency evaluations, deviation requests and/or exemption requests, as appropriate. Use of industry accepted Fire Modeling Programs serve as an upgrade to this current practice. As an alternative to obtaining NRC review and concurrence for these types of equivalency evaluations, the Resolution Methodology proposes an additional enhancement to the equivalency evaluation process by the introduction of an Expert Panel review and concurrence for those instances where fire modeling is used to disposition an identified MSO Impact.

Fire Modeling used during for the disposition of MSOs must be performed consistent with the methods described in NUREG/CR-6850, using verified fire models as described in NUREG-1824. Additionally, process improvements developed for NFPA-805 applications should be considered, as applicable.

When selecting a fire size for the analysis, the 98% upper bound of the fire size should be used. Additionally, the location of the fire would include consideration of the pinch points for the cables, possible ignition of secondary combustibles, etc. For transient combustibles, any location within the plant should be considered unless it is physically impossible.

As discussed above, dispositions using Fire Modeling are not generically authorized by the NRC to be applied to MSOs categorized as required for hot shutdown component MSOs. Exemptions, deviations or LARs, depending on a licensee's current licensing basis, may be are required to use fire modeling for required for hot shutdown MSOs.

4.5.3.3 Fire PRA Disposition

Disposition using a Focused-Scope Fire PRA is performed using Chapter 5, Risk Significant Screening. As discussed above, dispositions using Focused-scope Fire PRA are not generically authorized by the NRC to be applied to MSOs categorized as required for hot shutdown component MSOs. Exemptions, deviations or LARs, depending on a licensee's current licensing basis, will may be required to use Focused-scope Fire PRAs for required for hot shutdown MSOs. The Licensee will need to review their existing Licensing basis to determine if a focused-scope Fire PRA is currently permitted. If not, a License Amendment may be required.

4.5.4 4.5.4 EXPERT PANEL REVIEW OF MSO DISPOSITION

As can be seen from Figure 4-1 above, MSOs dispositioned using the methods described in 3.4.2 or using the circuit failure criteria from Appendix B as explained above do not need to be reviewed by the Expert Panel. All other methods of disposition, however, need to be reviewed by the Expert Panel.

In this review, the Expert Panel will review the disposition for adequacy, as well as take into account additional deterministic factors, including whether the MSO is for a required for hot shutdown or an important to SSD component combination. This review includes:

1) Review the justification for disposition. Ensure the justification follows the guidance above (or in Chapter 5), and the justification is adequate.

2) Discuss the possible alternative dispositions for the MSO scenario, including traditional compliance methods discussed in 3.4.2.

The review in item 2 should include the uncertainty/sensitivity of the evaluation being performed, the effect the traditional compliance strategy would have on other MSOs or spurious operations, the cumulative effect of spurious operations and fire risk in the area, and other factors the Expert Panel determines are important.

The review of the disposition of an MSO using Fire PRA will vary slightly between the MSO using a focused-scope Fire PRA and a Full Fire PRA. With a full Fire PRA, the analysis of a compartment or area will include analysis of all potentially important fire scenarios. The expert panel should become familiar with the general compartment/area results, and the characteristics of the area that affect both overall risk and the risk for the MSO. These characteristics should be consistent, and given they are consistent; the expert panel review of the MSO analysis is somewhat simpler. With a Focused-scope Fire PRA, the expert panel will need to ensure that the characteristics affecting the MSO analysis are consistently and accurately applied. The sensitivity and uncertainty analysis should include the affects of assumptions made for the fire characteristics, including basic factors such as fire size assumptions, non-suppression probabilities, etc.

Refer to Appendix F for additional guidance on the Expert Panel review.

4.5.5 4.5.5 FEEDBACK TO THE GENERIC MSO LIST

As this and other MSO methods are implemented (e.g., implementation of NFPA 805), the MSO list has the potential to grow. For the method above, the following criteria should be used to determine if any new MSO should be added to the generic MSO list:

a. Any new MSO not on the generic list,

b. The MSO does not screen using the conservative screening in Chapter 5 (i.e., requires detailed Fire PRA to determine the risk), or is not analyzed using Fire PRA resulting in a compliance strategy being applied.

Each new MSO is to be provided to NEI and the responsible Owner's Group. When provided, the new MSO should include a preliminary classification as to whether the MSO is for a required for hot shutdown or an important to SSD component combination. The responsible Owner's Group will review the new MSO for generic applicability and revise their generic MSO list, as appropriate. NEI will add the new MSO list to their webpage and notify the industry of the change. The list of MSOs will be maintained on the NEI Webpage and by each responsible Owner's Group.

4.6 DOCUMENTATION

Documentation should be included in the Fire Area Assessment, as discussed in 3.4.2.5 above. The Fire Area Assessment may refer to additional analysis supporting the disposition such as the PRA or Fire Modeling Analysis.

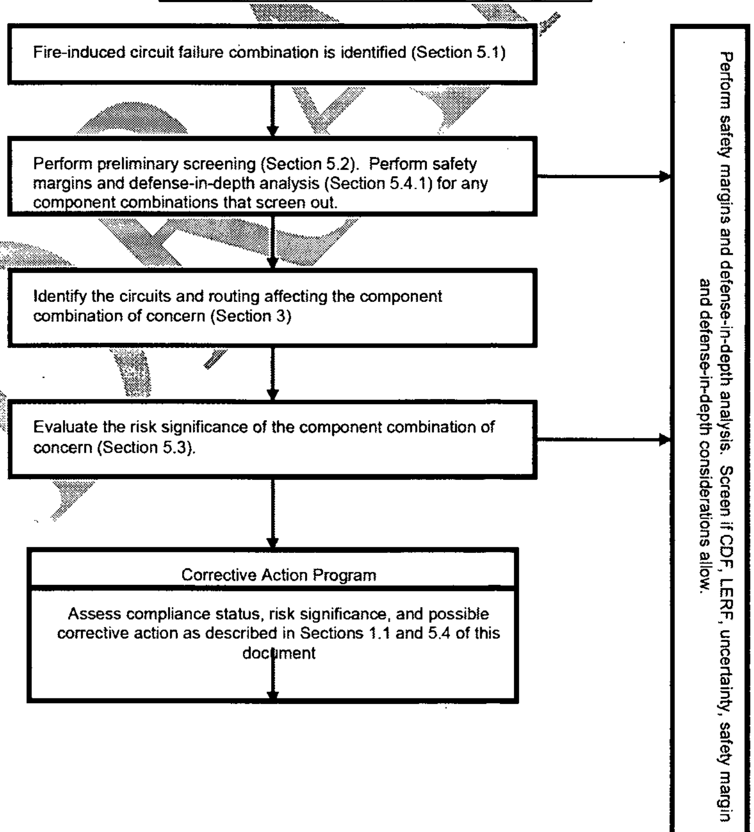
5 RISK SIGNIFICANCE ANALYSIS

This section provides a method for determining the risk significance of identified fire induced circuit failure component combinations (MSOs) to address the risk significance of the current circuit failure issues.

Section 5.1 provides a translation of the plant specific MSOs that are selected for focused-scope fire PRA review into scenarios that can be analyzed by in a Fire PRA.

Section 5.2 focuses on the preliminary screening of these circuit failures to determine if more detailed analysis methods are warranted. Section 5.3 provides a quantitative method for evaluating the risk significance of identified component combinations. Section 5.4 covers integrated decision making for the risk analysis, including consideration of safety margins and defense-in-depth considerations.

Figure 5-1
Simplified Process Diagram



5.1 COMPONENT COMBINATION IDENTIFICATION

The purpose of this initial step is to translate the plant specific MSOs that are selected for Focused-scope Fire PRA review into scenarios that can be analyzed by in a Fire PRA.

5.1.1 CONSIDERATION OF CONSEQUENCES

This first step limits consideration to component combinations whose mal-operation could result in loss of a key safetysafe shutdown function, or in immediate, direct, and unrecoverable consequences comparable to high/low pressure interface failures. The component combinations identified in Chapter 4 above, would initially be reviewed to ensure that the MSO scenario results in a consequence of concern. If the MSO scenario does not result in one of the above consequences, the MSO may be qualitatively screened as low risk. This review must take into account all possible fire-induced failures, and the overall affect effect of the MSO on the plant risk.

Comment [h50]: This screening criteria will not catch more subtle failure modes and scenarios with this approach.

Comment [rhg51]: The combination of component failures/malfunctions/etc. should be an all-or-none type of screening at this point, without regard to "risk." In core damage terminology (for the sake of simplicity), either the combination can cause core damage (a minimal cut set) or it cannot. Whether or not the risk is low, medium or high is a question that is asked only after the candidate set of combinations (minimal cut sets) has been identified, since only these are retained. So, the so-called "qualitative screening" is not based on risk significance, but actually on whether or not the undesirable consequence(s) can even be achieved. This is not a "risk screening."

5.1.2 SELECTION OF MSO SCENARIOS TO BE ANALYZED

The purpose of this review is to ensure the proper level of risk is assessed for the possible component combinations prior to screening a combination for consideration. Given an MSO combination is provided, this combination will result in one or more PRA scenarios scenario of interest. The MSO scenario may need further definition at this point, including identification of additional fire-damaged components, timing issues, etc. Timing issues may include details such as component A would need to spuriously operate before component B for the scenario to affect safe shutdown.

Comment [rhg52]: Again, this is a go/no-go situation – there is no quantitative considerations at this point, so no "risk" evaluation.

At the end of this step, the MSO description would be translated into one or more scenarios that can be analyzed using a focused scope Fire PRA. The scenarios may be slightly different for each fire area or compartment where the MSO is possible, but this differentiation would occur later in the steps below.

5.2 PRELIMINARY SCREENING

The "risk screening tool" presented here is taken directly from Reference 7.4.43, as updated by the original authors for the USNRC. It is the result of the NRC's effort to develop this method. Adapted from NEI 00-01 Rev 0 [Ref. 7.4.46], it is relatively simple, based on measures readily available from the FP SDP [Ref.7.4.45], but conservative in that credits are limited to ensure the likelihood of "screening out" a circuit issue that could be of greater-than-very-low-risk-significance is minimized. Examples of this conservatism include use of generic fire frequencies based on fire zone or major components; treatment of potentially independent spurious actuations as dependent (i.e., no multiplication of more than two probabilities); crediting of manual suppression in a fire zone only if detection is present there; and choice of the most stringent screening criterion from Ref. 7.4.46. Note that none of the "additional considerations" among the screening factors below is permitted to introduce a factor <0.01 as a multiplier.

Comment [rhg53]: An electronic update to the original reference is attached rather than going through this section to show specific replacements. A complete replacement, adjusting for the NEI 00-01 headings, format, and style, would probably be the best way to perform this update. This whole section needs an update.

5.2.1 SCREENING FACTORS

The following screening factors are used.

5.2.1.1 Fire Frequency (F)

Table 1.4.2 of the FP SDP [Ref. 7.4.45] (modified here as Table 4-5 for use in the subsequent example application) and Table 4-3 of EPRI-1003111 [Ref. 7.4.44] list the mean fire frequencies at power by plant location and ignition source. The frequencies are characteristic of a fire occurring anywhere within the location. The mean fire frequencies by location range from a minimum of ~0.001/yr (Cable Spreading Room in Ref. 7.4.45; Battery Room in Ref. 7.4.44) to maximum of ~0.1/yr (Boiling Water Reactor Building in Ref. 674.45; Turbine Building in both Ref.7.4.44 and Ref. 7.4.45). These values used in Ref. 7.4.44 and Ref. 7.4.45 eliminate fire events judged to be "non-challenging." Considering uncertainties in their probability distributions (somewhat reflected in the two-sided 90% upper and lower confidence bounds in Ref. 7.4.44), the following ranges for fire frequencies are used:

- HIGH, ≥0.03/yr but ≤1/yr
- MEDIUM, ≥0.003/yr but <0.03/yr
- LOW, <0.003/yr

5.2.1.2 Probability of Spurious Actuation (P)

Table 2.8.3 of the Ref. 7.4.45 (modified here as Table 5-6 for use in the subsequent example application) and Tables 7.1 and 7.2 of Ref. 7.4.40 provide point estimates for the probability of spurious actuation ranging from a minimum of "virtually impossible" (armored inter-cable interactions in Ref. 7.4.45; armored thermoset inter-cable interactions in Ref. 7.4.40) to a maximum approaching 1.0 ("no available information about cable type or current limiting devices" in Ref. 7.4.45; any intra-cable short in Ref. 7.4.40). Ref. 7.4.40 also provides ranges for these estimates. The lowest non-zero values are 0.01 for "in-conduit, inter-cable only" in Ref. 7.4.45.

NRC Regulatory Issue Summary 2004-03 [Ref. 6.6.1] states that "for cases involving the potential damage of more than one multiconductor cable, a maximum of two cables should be assumed to be damaged concurrently". Therefore, no more than two multiple spurious actuations within separate cables are assumed to be independent when calculating the probability P, i.e., no more than two of the spurious actuation probabilities in Ref. 7.4.40 or Ref. 7.4.45 should be multiplied together. Consideration of this conservative assumption and the ranges cited in these reports suggests the following ranges for conditional probability of spurious actuation:

- HIGH, >0.3 but ≤1 _
- MEDIUM, ≥0.03 but <0.3
- LOW, ≥0.003 but <0.03 _
- VERY LOW, <0.003

Multiplying F and P over their respective ranges yields the maxima shown in Table 5-1 for the pairings F*P.

5.2.1.3 Additional Considerations

The F*P pairings represent the frequency of a fire-induced spurious actuation of a component combination. Core damage will occur only if (1) the fire is localized and severe enough to induce spurious actuation; (2) the fire is not suppressed prior to inducing the spurious actuation; and (3) other non-fire related contingencies, including human actions and equipment operation, are unsuccessful. Thus, for core damage to occur, there must also be a "challenging" fire; failure to suppress the fire prior to the spurious actuation; and failure to avoid core damage via non-fire means, represented by the conditional core damage probability (CCDP). The number of potentially vulnerable locations (zones) addresses possible variation in the screening threshold frequency depending upon the number of zones that the equipment traverses where there is a potential for fire damage.

5.2.1.4 Challenging Fire (G)

Fires can vary in magnitude, ranging from small, essentially self-extinguishing, electrical relay fires to complete combustion of an entire compartment. To estimate how challenging a fire could be for screening purposes, we consider the largest fire source in the zone and combustible type. Ref. 7.4.45 specifies categories (bins) for both fire type and size.[4] The factor (G), independent from the fire frequency, for a challenging fire is based on combustible type.

Table 2.3.1 of the Ref. 7.4.45 (modified here as 5-7 for use in the subsequent example application) assigns both 50th and 95th percentile fires for various combustibles to fire size bins ranging from heat release rates of 70 kW to 10 MW. Fires in the 70 kW-200 kW range are considered small; 200 kW-650 kW moderate; and ≥650 kW large. Typically, some train separation is built into plant designs in accordance with NRC Regulatory Guide 1.75 [Ref. 7.4.50]. Therefore, small fires are not likely to damage separated trains. Although moderate fires are more damaging, some credit for train separation can still be expected.

Based on the above, for small or moderate size fires that are not expected to be challenging, such as small electrical fires, a factor of 0.01 is applied. For moderate severity fires, including larger electrical fires, a factor of 0.1 is applied. For large fires, including those from oil-filled transformers or very large fire sources, the factor is 1.

5.2.1.5 Fire Suppression (S)

Both automatic and manual fire suppression (including detection by automatic or manual means) are creditable. It is assumed that automatic is preferred and a more reliable suppressor than manual, suggesting a non-suppression probability of 0.01 for automatic and 0.1 for

[4] Room size and other spatial factors also influence how challenging a fire can be. However, we do not consider these for screening purposes.

manual.[5] If automatic can be credited, then manual will not. Manual will only be credited if automatic cannot. Thus, the product F*P will be reduced by a factor of either 0.01 (if automatic suppression is creditable) or 0.1 (if automatic suppression is not creditable, but manual is).[6] Both, implying a reduction by 0.001, will never be credited. Thus, the maximum reduction in the product F*P that can be achieved through consideration of fire suppression is 0.01.

Note the following exception. Energetic electrical fires and oil fires, which are likely to be the most severe fires at a nuclear power plant, may grow too quickly or too large to be controlled reliably by even a fully creditable automatic suppression system. This is not due to degradation of the system but to the characteristics of the fire. Therefore, for fire zones where energetic electrical[7] or oil fires may occur, no credit will be given to manual suppression, while that for automatic will be reduced to 0.1.

5.2.1.6 CCDP (C)

There should be at least one fire-independent combination of human actions and equipment operation to prevent core damage, provided these are not precluded by the fire itself or its effects. To incorporate this, a CCDP, given the preceding ignition and failures, must be appended to the F*P*G*S value. Table 2.1.1 of the FPSDP (modified here as Table 5-8 for use in the subsequent example application) specifies three types of "remaining mitigation capability" for screening CCDP unavailabilities based on safe shutdown path. These are (1) 0.1 if only an automatic steam-driven train can be credited; (2) 0.01 if a train that can provide 100% of a specified safety function can be credited; and (3) 0.1 or 0.01 depending upon the credit that can be assigned to operator actions.[8]

For this last group, a value of 0.1 is assumed if the human error probability (HEP) lies between 0.05 and 0.5, and 0.01 if the HEP lies between 0.005 and 0.05. Credit is based on additional criteria being satisfied, as listed in Table 2.1.1 of the FPSDP.[9]

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[5] To credit manual suppression, this method assumes that detection must be present in the fire zone.

[6] If neither is creditable (e.g., no automatic suppression system and timing/location/nature/intensity of fire precludes manual suppression), there will be no reduction in the product F * P. This would apply to scenarios where the source and target are the same or very close to one another. Fire suppression may not be creditable due to insufficient time for suppression prior to cable damage. This is expected to be a rare event and should not be considered unless the configuration clearly shows that immediate component damage is likely to occur.

[7] Ref. 7.4.48 documents energetic faults only in nuclear power plant switchgear >4 kV. The FP SDP considers both switchgear and load centers as low as ~400 V subject to energetic faults. Consistent with the nature of this screening tool, the FP SDP approach is suggested (i.e., considering switchgear and load centers down to ~400 V as subject to energetic faults).

[8] Even the lower value of 0.01 is considered conservative based on Ref. 8, which cites several examples where non-proceduralized actions by plant personnel averted core damage during severe fires. Of the 25 fires reviewed, none resulted in core damage.

[9] These criteria include available time and equipment; environmental conditions; procedural guidance; and nature of training.

5.2.1.7 Factor for Number of Vulnerable Zones (Z)

While there is no way to know a priori the exact number of fire zones through which the vulnerable equipment will pass, or the number of these where there is potential for fire damage, something on the order of 10 zones will be conservatively assumed for screening purposes. Typically, plant control wiring follows a relatively direct path from control cabinet to actuated device, so it is unlikely that 10 fire zones would be involved. In many plants, the number of fire zones involved could be as small as 2 or 3. Theoretically, the total frequency of core damage from spurious actuation would be the sum of the frequencies from the individual zones. In general, a higher value would be expected for a higher number of zones. Thus, some type of credit is given for a scenario where the number of vulnerable zones is less than the assumed generic number of 10, say, e.g., five zones or less.

This type of credit would translate into an increase in the screening threshold frequency per zone (call it X), or equivalently a decrease in the zonal core damage frequency (call it D). If we assume limiting the number of vulnerable zones to five or less produces at least a 10% increase in the allowable frequency for zonal screening, i.e., 1.1X, this translates into a decrease in the zonal core damage frequency (D) by a factor Z. To estimate Z, consider the following.

For zonal core damage frequency (D) to meet the threshold (X), D must be < X. For five or less vulnerable zones, we allow an increase to at least 1.1X, such that the zonal core damage frequency meets this new threshold, D < 1.1X. Relative to the original threshold, X, we require X > D/1.1, or X > 0.9D. The factor 0.9 corresponds to a maximum value for Z for five or less vulnerable zones.

5.2.2 SIX-FACTOR FREQUENCY OF CORE DAMAGE (F*P*G*S*C*Z)

The maximum frequencies that result from assuming the maximum credits for G (0.01), S (0.01), C (0.01) and Z (0.9), i.e., a joint credit of 9E-7, for the F*P pairings are shown in Table 4-2. Revision 0 of this document stated that "[t]he criteria for risk significance are ... consistent with Regulatory Guide 1.174 [Reference 7.4.50] guidance." The plant-specific risk significance screening in Revision 0 states that "the criteria for determining that component combinations are not risk significant are as follows:

- If the change in core damage frequency (delta-CDF) for each component combination for any fire zone is less than 1E-7 per reactor year, AND
- If the delta-CDF for each component combination is less than 1E-6 per reactor year for the plant, i.e., sum of delta-CDF for all fire zones where circuits for the component combinations (circuits for all) are routed, AND
- If the delta-CDF for each fire zone is less than 1E-6 per reactor year for the plant, i.e., the sum of delta-CDF for all combinations of circuits in the fire zone."

Of these three criteria, the most stringent is the first, requiring the delta-CDF to be <1E-7/yr. This seems to be the appropriate criterion to apply to the Six-Factor Frequency of Core Damage since this is the preliminary screening stage.[10] In Table 5-2, neither of the shaded boxes satisfies this criterion exclusively, while the unshaded boxes may satisfy this criterion in certain cases.

5.2.3 FINAL SCREENING TABLE

Restricting the values for challenging fires (G), fire suppression (S), CCDP (C), and the factor for number of vulnerable zones (Z) as shown via the point assignments below,[11] the cases where this criterion is satisfied are indicated in Table 5-3. These correspond to the cases where preliminary "screening to green" can be assumed successful.[12]

5.2.3.1 Steps to Use Table 5-3

1. Determine the fire frequency. Use either the generic fire zone frequency or the fire frequency refined by the component-based fire frequency tool in the FPSDP.
2. Determine the probability of spurious actuation from the FPSDP. If multiple spurious actuations are involved, no more than two of the spurious actuation probabilities should be multiplied together.
3. Determine the block on the table that corresponds to the fire frequency and probability of spurious actuation.
4. Determine if the fire is challenging and, if so, to what degree. Use the fire type for the single largest fire source in the zone. For example, a zone with both small and large fires would be considered subject to large fires only (i.e., there is no combination).
5. Determine the fire suppression factor. If both manual and automatic suppression can be credited, the more effective (automatic) is the only one receiving credit (i.e., there is no combination).[13]
6. Determine the CCDP. If no mitigation capability remains, assume a CCDP = 1.
7. Determine the number of vulnerable zones.
8. Sum the points as assigned below to determine if the zone can be screened to green.

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[10] For this preliminary screening delta-CDF is conservatively approximated by CDF itself.

[11] Each point is roughly equivalent to a factor of ten reduction or the negative exponent of a power of 10, e.g., 1 point corresponds to 1E-1 = 0.1, 2.5 points correspond to 1E-2.5 = 0.003

[12] "Screening to green" in the FPSDP indicates a finding of very low risk-significance that need not be processed further.

[13] Credit is reduced for energetic electrical and oil fires.

Challenging Fires (G)

Large fires = 0 point
Moderate fires = 1 point
Small fires = 2 points

Fire Suppression (S)

None fully creditable = 0 point
Only manual fully creditable = 1 point [14](reduced to 0 point for energetic electrical or oil fires)
Automatic fully creditable = 2 points (reduced to 1 point for energetic electrical or oil fires)

CCDP (C)

No mitigation capability creditable = 0 point
Only an automatic steam-driven train or operator actions with 0.05 < HEP < 0.5 creditable = 1 point[15]
A train providing 100% of a specified safety function creditable = 2 points

Factor for Number of Vulnerable Zones (Z)

Greater than five zones = 0 point
Five zones or less = 0.5 point

As shown in Table 5-3, screening at this preliminary stage is not possible if the fire frequency is HIGH and the probability of spurious actuation is HIGH or MEDIUM. All other combinations may be screenable if the point criteria are satisfied.

5.2.3.2 Relative Ranking Evaluation

For analyses where all zones screen, Table 5-4 can be used to evaluate which zone is likely to be the most risk-significant. Table 5-4 converts the F*P maximum frequencies from Table 5-1 into their point equivalents for each F*P pairing.[16] The pairing point equivalent should be added to the total point credits from the preliminary screening to establish the total risk-significance of each zone. The zone with the lowest point total is viewed as the most risk-

[14] As mentioned earlier, detection must be present in the fire zone to take credit for manual suppression.

[15] As mentioned earlier, the credit for operator actions is based on additional criteria being satisfied, including available time and equipment; environmental conditions; procedural guidance; and nature of training.

[16] Recall that each point is roughly equivalent to a factor of ten reduction, or the negative exponent of a power of 10. Thus, the F*P pairing for HIGH-HIGH in Table 1 (1/yr = 1E-0/yr) receives 0 point in Table 4, while that for LOW-VERY LOW (1E-5/yr) receives 5 points.

significant. At least this one zone should be processed through the FPSDP to verify the validity of the tool, i.e., to verify that the tool did not give a false positive. These FPSDP results, and not the results from the preliminary screening tool, should be used to determine the risk-significance of the finding in Phase 2 of the FPSDP.

5.2.4 EXAMPLE APPLICATION

The following example, somewhat exaggerated for illustration purposes, presents the use of the preliminary screening tool. Assume an FPSDP inspection finding that cables for a pressurized water reactor (PWR) power-operated relief valve and its accompanying block valve are routed through the following five fire zones: the auxiliary building, battery room, cable spreading room, emergency diesel generator room, and main control room. Fire damage to the cables can result in the spurious opening of these valves. The cables are thermoset throughout and are encased in an armor jacket only in the battery room. Table 5-6 assigns a probability of spurious actuation of 0.6 to thermoset cables for which no other information is known, which lies in the HIGH range in Table 5-3.

The auxiliary building and emergency diesel generator room are protected by automatic sprinkler systems. The switchgear room has an automatic Halon-1301 system. The battery room and main control room have smoke detectors but rely on hand-held extinguishers and hoses for manual fire suppression.

5.2.4.1 Auxiliary Building

Table 5-5 indicates a generic fire frequency for an auxiliary building of 0.04/yr, which lies in the HIGH range in Table 5-3. Since the corresponding probability of spurious actuation is also HIGH, this zone cannot be screened using this tool.

5.2.4.2 Battery Room

Table 5-5 indicates a generic fire frequency for a battery room of 0.004/yr, which lies in the MEDIUM range. Since the cable is armored in this room, the probability of spurious actuation is virtually nonexistent, corresponding to the VERY LOW range. Table 5-3 indicates that preliminary screening is possible for this zone with > 3 points.

Small fires can be expected in the battery room, which earns 2 points from Table 5-7 for fire size (G). Only manual suppression can be credited because of the portable fire extinguishers and automatic detection, producing 1 point for fire detection/suppression (S). No mitigation capability is creditable since both DC trains could be lost in a battery room fire; no point is assigned from Table 5-8 for CCDP (C).[17] There are a total of 5 vulnerable zones, so 0.5 point is assigned for the number of vulnerable zones (Z). The points for the battery room total to 3.5, therefore permitting preliminary screening.

[17] This conservative assumption of total loss of DC power is for illustration only.

5.2.4.3 Cable Spreading Room - Cables Only

Table 5-5 indicates a generic fire frequency for a cable spreading room with cables only of 0.002/yr, which lies in the LOW range. With no other information known, the thermoset cable has a probability of spurious actuation of 0.6 from Table 5-6, i.e., lying in the HIGH range in Table 5-3. As a result, >4.5 points are needed to screen this zone.

Small fires can be expected in the cable spreading room, which earns 2 points from Table 5-7 for fire size. The automatic Halon extinguishing system results in a credit of 2 points for fire detection/suppression. A remote shutdown station can be credited, meriting 1 point from Table 5-8 for CCDP.[18] There are a total of 5 vulnerable zones, so 0.5 point is assigned. The points for the cable spreading room total to 5.5, therefore permitting preliminary screening.

5.2.4.4 Emergency Diesel Generator Building

Table 5-5 indicates a generic fire frequency for an emergency diesel generator room of 0.03/yr, which lies in the HIGH range. With no other information known, the thermoset cable has a probability of spurious actuation of 0.6 from Table 5-6, i.e., lying in the HIGH range in Table 5-3. As a result, this zone cannot be screened using this tool.

5.2.4.5 Main Control Room

Table 5-5 indicates a generic fire frequency for a main control room of 0.008/yr, which lies in the MEDIUM range. With no other information known, the thermoset cable has a probability of spurious actuation of 0.6 from Table 5-6, i.e., lying in the HIGH range in Table 5-3. As a result, >5.5 points are needed to screen this zone.

Moderate-sized fires are expected in the main control room due to the large number of cables and electrical equipment present. Therefore, 1 point is assigned from Table 5-7 for fire size. The portable fire extinguishers and automatic smoke detection merit 1 point fire detection/ suppression. One of two completely independent and redundant trains providing 100% of the specified safety function (Residual Heat Removal)[19] remains fully creditable, meriting 2 points from Table 5-8 for CCDP. There are a total of 5 vulnerable zones so 0.5 point is assigned. The points for the main control room total to only 4.5, therefore preventing preliminary screening.

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[18] A human error probability for Operator Action between 0.05 and 0.5 is assumed for operator actions at a remote shutdown station, which yields a credit of 1 point. As per Table 8, this credit also assumes that: (1) sufficient time is available; (2) environmental conditions allow access, where needed; (3) procedures describing the appropriate operator actions exist; (4) training is conducted on the existing procedures under similar conditions; and (5) any equipment needed to perform these actions is available and ready for use.

[19] Residual Heat Removal need not be the only safety function to achieve safe shutdown. This is an assumption for illustration only.

5.2.4.6 Conclusions

Only the Battery Room and Cable Spreading Room could be screened using this tool. The remaining zones would require more detailed analyses to assess each delta-CDF through the FPSDP. In this example the cables ran through fire zones with different fire initiator frequencies, cable types (and therefore spurious actuation probabilities), potential fire sizes, suppression systems, and core damage mitigation capabilities. The example illustrates that it is easier to screen zones with lower fire initiator frequencies and probabilities of spurious actuation than zones with higher values. Fire zones with lower F*P pairings require less credit from the "additional considerations" (G*S*C*Z) to satisfy the screening threshold of delta-CDF < 1E-7/yr.

5.2.5 SUMMARY

This risk-screening tool can be applied to fire-induced, circuit spurious actuation scenarios identified in 5.1 above. These findings typically involve the multiple fire zones through which the circuits pass. To streamline the FPSDP, the tool screens zones where the "circuit issue" is expected to be of very low risk-significance based on (1) the fire frequency in the zone where the circuits are located; (2) the probability of spurious actuation; and (3) automatic or manual suppression, or an alternate means to achieve hot shutdown.

The tool estimates six factors to calculate the frequency of core damage: (1) zonal fire frequency; (2) spurious actuation probability; (3) challenging fire factor; (4) probability of non-suppression; (5) CCDP; and (6) factor based on number of vulnerable zones. The tool determines if a fire zone, once it has been assigned to a fire frequency-spurious actuation probability pairing (i.e., the first two factors), can be screened at a maximum delta-CDF threshold of 1E-7/yr based on a point system for the remaining four factors.

TABLE 5-1. Maxima for the Pairings F*P (With Round off to the Nearest "3" or "1" for Convenience)		Fire frequency (F)		
		HIGH, ≥0.03/yr but ≤1/yr	MEDIUM, ≥0.003/yr but <0.03/yr	LOW, <0.003/yr
Probability of spurious actuation (P)	HIGH, ≥0.3 but ≤1	1/yr	0.03/yr	0.003/yr
	MEDIUM, ≥0.03 but <0.3	0.3/yr	0.009/yr (~0.01/yr)	9E-4/yr (~0.001/yr)
	LOW, ≥0.003 but <0.03	0.03/yr	9E-4/yr (~ 0.001/yr)	9E-5/yr (~1E-4/yr)
	VERY LOW, <0.003	0.003/yr	9E-5/yr (~1E-4/yr)	9E-6/yr (~1E-5/yr)

TABLE 5-2. Maxima That Result from Maximum Credits for G (0.01), S (0.01), C (0.01) and Z (0.9), i.e., a Joint Credit of 9E-7		Fire frequency (F)		
		HIGH, ≥0.03/yr but ≤1/yr	MEDIUM, ≥0.003/yr but <0.03/yr	LOW, <0.003/yr
Probability of spurious actuation (P)	HIGH, ≥0.3 but ≤1	9E-7/yr	3E-8/yr	3E-9/yr
	MEDIUM, ≥0.03 but <0.3	3E-7/yr	9E-9/yr	9E-10/yr
	LOW, ≥0.003 but <0.03	3E-8/yr	9E-10/yr	9E-11/yr
	VERY LOW, <0.003	3E-9/yr	9E-11/yr	9E-12/yr

TABLE 5-3. Point Requirements for Screening (Note use of ">" vs. "≥," i.e., points must EXCEED numbers shown)		**Fire frequency (F)**		
		HIGH, ≥0.03/yr but ≤1/yr	**MEDIUM, ≥0.003/yr but <0.03/yr**	**LOW, <0.003/yr**
Probability of spurious actuation (P)	**HIGH, ≥0.3 but ≤1**	Do not screen	Screen to green with > 5.5 points	Screen to green with > 4.5 points
	MEDIUM, ≥0.03 but <0.3	Do not screen	Screen to green with > 5 points	Screen to green with > 4 points
	LOW, ≥0.003 but <0.03	Screen to green with > 5.5 points	Screen to green with > 4 points	Screen to green with > 3 points
	VERY LOW, <0.003	Screen to green with > 4.5 points	Screen to green with > 3 points	Screen to green with >2 points

TABLE 5-4. Establishing Relative Risk Ranking When All Zones Preliminarily Screen[17]				
Fire frequency (F)	**Probability of spurious actuation (P)**	**Points**		
		Preliminary screen total	**Table 4-1 equivalents**	**Risk-ranking total**
HIGH	**HIGH**	(Zone A - 4)	0	(Zone A - 4)
	MEDIUM		0.5	
	LOW	(Zone B - 3)	1.5	(Zone B - 4.5)
	VERY LOW		2.5	
MEDIUM	**HIGH**	(Zone C - 2)	1.5	(Zone C - 3.5)
	MEDIUM		2	
	LOW	(Zone D - 2.5) (Zone E - 3)	3	(Zone D - 5.5) (Zone E - 6)
	VERY LOW		4	
LOW	**HIGH**		2.5	
	MEDIUM	(Zone F - 3.5)	3	(Zone F - 6.5)
	LOW		4	
	VERY LOW	(Zone G - 1.5)	5	(Zone G - 6.5)

Table 5-4 includes an example (items in parentheses) where none of a total of seven zones satisfied the preliminary screening criteria of Table 5-3. When ranked relative to one another using the point equivalents from Table 5-1, Zone C proved to be of highest relative risk-significance (lowest total points, 3.5). At a minimum, Zone C would be processed through Phase 2 of the FPSDP (followed by Zone A, Zone B, etc., if the analyst chose to process more).

TABLE 5-5. Generic Location Fire Frequencies	
Room Identifier	**Generic Fire Frequency (Range)**
Auxiliary Building (PWR)	4E-2 (HIGH)
Battery Room	4E-3 (MEDIUM)
Cable Spreading Room - Cables Only	2E-3 (LOW)
Cable Spreading Room - Cables Plus Other Electrical Equipment	6E-3 (MEDIUM)
Cable Vault or Tunnel Area - Cables Only	2E-3 (LOW)
Cable Vault or Tunnel Area - Cables Plus Other Electrical Equipment	6E-3 (MEDIUM)
Containment - PWR or Non-inerted Boiling Water Reactor (BWR)	1E-2 (MEDIUM)
Emergency Diesel Generator Building	3E-2 (HIGH)
Intake Structure	2E-2 (MEDIUM)
Main Control Room	8E-3 (MEDIUM)
Radwaste Area	1E-2 (MEDIUM)
Reactor Building (BWR)	9E-2 (HIGH)
Switchgear Room	2E-2 (MEDIUM)
Transformer Yard	2E-2 (MEDIUM)
Turbine Building - Main Deck (per unit)	8E-2 (HIGH)

TABLE 5-6. Probabilities of Spurious Actuation Based on Cable Type and Failure Mode (Range)		
State of Cable Knowledge	**Thermoset**	**Thermoplastic**
No available information about cable type or current limiting devices	0.6 (HIGH)	
Cable type known, no other information known (NOI)	0.6 (HIGH)	
Inter-cable interactions only	0.02 (LOW)	0.2 (MEDIUM)
In conduit, cable type known, NOI	0.3 (HIGH)	0.6 (HIGH)
In conduit, inter-cable only	0.01 (LOW)	0.2 (MEDIUM)
In conduit, intra-cable	0.075 (MEDIUM)	0.3 (HIGH)

TABLE 5-7
General Fire Scenario Characterization Type Bins Mapped to Fire Intensity Characteristics

Fire Size Bins	**Generic Fire Type Bins with Simple Predefined Fire Characteristics (Points Assigned)**					
	Small Electrical Fire (2 points)	**Large Electrical Fire (1 point)**	**Indoor Oil-Filled Transformers (0 point)**	**Very Large Fire Sources (0 point)**	**Engines and Heaters (2 points)**	**Solid and Transient Combustibles (2 points)**
70 kW	50_{th} %ile fire				50_{th} %ile fire	50_{th} %ile fire
200 kW	95_{th} %ile fire	50_{th} %ile fire			95_{th} %ile fire	95_{th} %ile fire
650 kW		95_{th} %ile fire	50_{th} %ile fire	50_{th} %ile fire		
2 MW			95_{th} %ile fire			
10 MW				95_{th} %ile fire		

TABLE 5-8. Total Unavailability Values for SSD Path-Based Screening CCDP	
Type of Remaining Mitigation Capability	**Screening Unavailability Factor (Points Assigned)**
1 Automatic Steam-Driven Train: A collection of associated equipment that includes a single turbine-driven component to provide 100% of a specified safety function. The probability of such a train being unavailable due to failure, test, or maintenance is assumed to be approximately 0.1 when credited as "Remaining Mitigation Capability."	0.1 (1 point)
1 Train: A collection of associated equipment (e.g., pumps, valves, breakers, etc.) that together can provide 100% of a specified safety function. The probability of this equipment being unavailable due to failure, test, or maintenance is approximately 0.01 when credited as "Remaining Mitigation Capability."	0.01 (2 points)
Operator Action Credit: Major actions performed by operators during accident scenarios (e.g., primary heat removal using bleed and feed, etc.). These actions are credited using three categories of human error probabilities: **(1) Operator Action = 1.0, which represents no credit given;** **(2) Operator Action = 0.1, which represents a failure probability between 0.05 and 0.5; and** **(3) Operator Action = 0.01, which represents a failure probability between 0.005 and 0.05.** **Credit is based upon the following criteria being satisfied:** **(1) sufficient time is available;** **(2) environmental conditions allow access, where needed;** **(3) procedures describing the appropriate operator actions exist;** **(4) training is conducted on the existing procedures under similar conditions; and** **(5) any equipment needed to perform these actions is available and ready for use.**	1.0 (0 point), 0.1 (1 point), or 0.01 (2 points)

5.3 PLANT-SPECIFIC RISK SIGNIFICANCE SCREENING

Based on the evaluations performed in Section 5.2 and Section 3 of this document, the licensee may determine that additional safety significance analysis is warranted. The NRC's revised Fire Protection SDP (FPSDP) [Ref 7.4.45] is a useful tool for this purpose; it will be used by NRC inspectors evaluating the risk significance of circuit failure findings. It calculates the change in Core Damage Frequency for the finding. Other deterministic or probabilistic means may be employed, including plant-specific PRA calculations. Plant-specific PRA calculations should utilize the results of EPRI Report 10082391011989, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities." (NUREG/CR-6850), as updated by the NFPA-805 FAQ process where appropriate."

Comment [rhg54]: Is this different from "risk?" If not, use "risk." If so, clarify.

Comment [h55]: Why not recommend that NUREG/CR-6850 be used?

Comment [rhg56]: Add reference to RIS 2007-19. "Where appropriate," or similar wording, is provided to indicate that some FAQ resolutions related to fire PRA apply universally, whether or not part of the NFPA-805 process.

5.3.1 EPRI/NEI TEST RESULTS

EPRI TR-1006961, "Spurious Actuation of Electrical Circuits due to Cable Fires, Results of an Expert Elicitation" (Reference 7.4-39)), is referenced in both the preliminary screening and detailed screening in the determination of delta-CDF. More information about these results is provided here.

Comment [rhg57]: I don't believe there is a previous reference to this document.

The expert panel report provides a general methodology for determining spurious operation actuation probabilities. P_{SA} is given by the product:

$P_{SA} = P_{CD} * P_{SACD}$

P_{CD} = The probability of cable damage given a specified set of time-temperature and fire-severity conditions, and

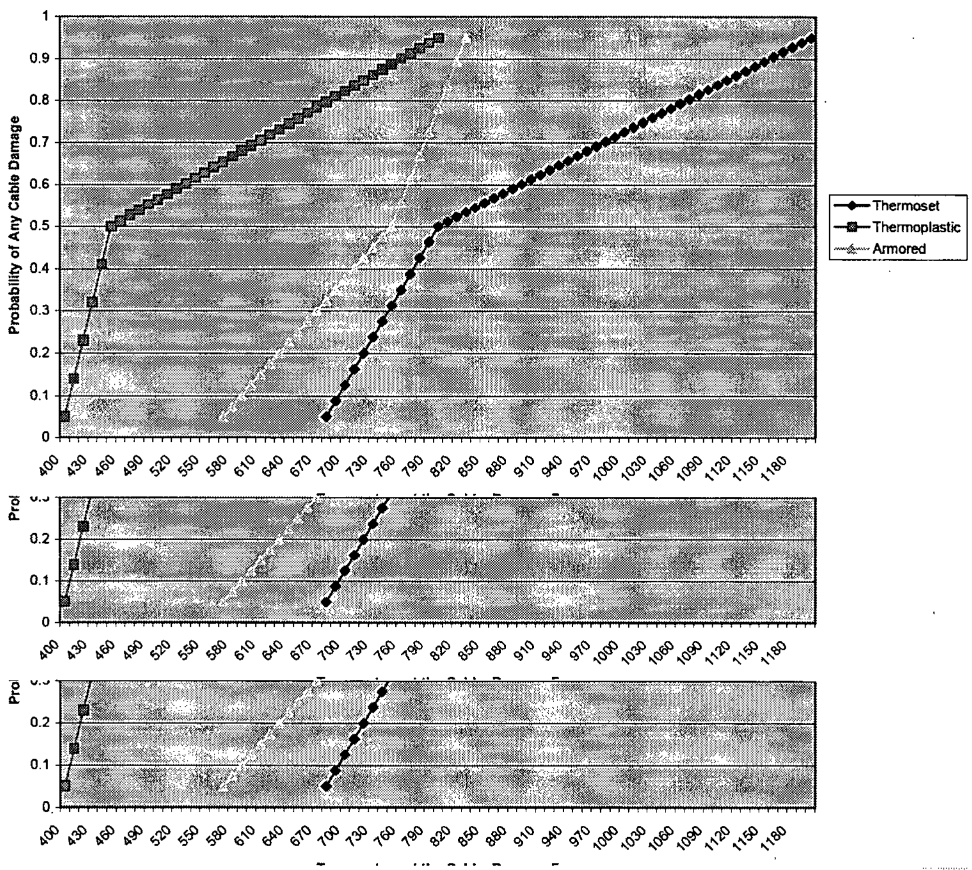
P_{SACD} = The probability of spurious actuation given cable damage

P_{CD} can be calculated using fire modeling, taking into account the factors affecting damage and the expected time response for manual suppression. Additionally, the expert panel report provides fragility curves for cable damage versus temperature for thermoset, T-thermoplastic and armored cables. This curve is provided below:

Comment [rhg58]: If there is an implicit assumption here that automatic suppression would respond so quickly that damage would not occur, this needs to be stated, rather than automatically defaulting to manual suppression. If this assumption is not implicit, then the use of suppression with either specifying manual or automatic would seem more appropriate.

FIGURE 5-2

Fragility Curves for Thermoset, Thermoplastic, and Armored Cable Anchored to the the 5%, 50%, and 95% Probability Values for P_{CD} (Reference 76.4.39 Figure 7-1)



There is a considerable body of test information on cable damageability tests, the results of which are not significantly different from these curves. Information on cable damageability is available from these other tests that the analyst may use in lieu of this curve.

This figure is not used in the preliminary screening process, meaning $P_{CD} = 1$ and the spurious operation probability is conservatively estimated as P_{SACD}. For the detailed screening (Section 5.3), P_{CD} can be factored in, given analysis is performed to determine maximum cable temperature for the fire scenario being analyzed. The pilot reports did not use P_{CD} for either screening process.

Comment [rhg59]: This IS Section 5.3. Is some other section meant here?

P_{SACD} can be estimated using Table 5-9. Some general guidance on this is as follows:

- Values in the table, other than B-15, assume control power transformers (CPTs) or other current limiting devices are in the circuit. To determine the probability of a spurious actuation without a CPT or other current limiting device in the circuit, the listed value should be multiplied by a factor of 2 * [$P_{SACD(B-15)}/P_{SACD(B-1)}$] .

- Based on the Reference 7.54-39, when two P_{SACD} (P_{SA}) values are used in the fire PRA, they should be taken treated as independent events, provided the phenomena occur in different conductors conductors, i.e., – thus, the two PRA probabilities should be multiplied together.

  Additional guidance on the use of this table is provided in the expert panel report (Reference 7.4-39).

  EPRI TR-1003326, *Characterization of Fire-Induced Circuit Failures: Results of Cable Fire Testing*, provides supplemental information to the expert panel report. This report provides detailed analysis for each of the tests and characterizes the factors affecting circuit failures in much more detail than the expert panel report. One area discussed by this report is duration of spurious operation events. The test data used for the EPRI report shows that a majority of the circuit failures resulting in spurious operation had a duration of less than 1 minute. Less than 10% of all failures lasted more than 5 minutes, with the longest duration recorded for the tests equal to 10 minutes. The results of the testing described in this report are reflected in RIS 2004-03. Note that all testing being referenced in these documents was performed on AC grounded circuits. Hot short durations on DC circuits can not be predicted using this data.

Comment [rhg60]: These references are to rather outdated material. Both the guidance from the RIS and knowledge of spurious actuation durations have advanced significantly since CAROLFIRE and the NFPA-805 FAQ process. These advancements need to be considered in any detailed analysis.

TABLE 5-9
(SEE REFERENCE ~~7~~667.4-39, TABLE 7-2)
SUMMARY OF THE PROBABILITIES (P_{SACD})

Case #	Case	Short Description	P_{SACD} Best Estimate	High Confidence Range	Discussion Reference
		P_{SACD} BASE CASE			
B-1	P_{SACD} base case	M/C Tset cable intra-cable	0.30	0.10 – 0.50	7.2.3.1
B-2	P_{SACD} base case	1/C cable, Tset, inter-cable	0.20	0.05 – 0.30	7.2.3.2
B-3	P_{SACD} base case	M/C with 1/C, Tset, Inter-cable	0.01	0.005 – 0.020	7.2.3.3 as modified by EPRI test report
B-4	P_{SACD} base case	M/C with M/C, Tset inter-cable	0.001 – 0.005		7.2.3.4 as modified by EPRI test report
		P_{SACD} VARIANTS			
Thermoplastic Variants					
B-5	P_{SACD} variant	Same as #B-1 except thermoplastic	0.30	0.10 – 0.50	7.3.1, last paragraph
B-6	P_{SACD} variant	Same as #B-2 except thermoplastic	0.20	0.05 – 0.30	7.3.1, last paragraph
B-7	P_{SACD} variant	Same as #B-3 except thermoplastic	0.10	0.05 – 0.20	7.3.1, last paragraph
B-8	P_{SACD} variant	Same as #B-4 except thermoplastic	0.01 - 0.05		7.3.1, last paragraph
Armored Variant[20]					
B-9	P_{SACD} variant	Same as #B-1 except armored	0.075	0.02 - 0.15	7.3.2 bullet 5
B-10	Deleted				
Conduit Variants					
B-11	P_{SACD} variant	Same as #B-1 except in conduit	0.075	0.025 – 0.125	7.3.3 last bullet
B-12	P_{SACD} variant	Same as #B-2 except in conduit	0.05	0.0125 – 0.075	7.3.3 last bullet
B-13	P_{SACD} variant	Same as #B-3 except in conduit	0.025	0.0125 – 0.05	7.3.3 last bullet
B-14	P_{SACD} variant	Same as #B-4 except in conduit	0.005 - 0.01		7.3.3 last bullet
Control Power Transformer (CPT) Variant					
B-15	P_{SACD} variant	Same as #B-1 except without CPT	0.60	0.20 – 1.0	7.4.1

Comment [rhg61]: Need to note that these Sections refer to Reference 7.4-39, not this document.

[20] Recent fire-damage testing of armored cables indicates that the recommended value above is not applicable for ungrounded armored circuits.

5.3.2 LARGE EARLY RELEASE FREQUENCY EVALUATION (LERF)

Screening of any component combination requires the consideration of LERF prior to screening. LERF screening can be performed quantitatively or qualitatively, depending on the availability of quantitative analysis. The quantitative screening criteria for LERF are an order of magnitude lower than CDF:

- No LERF review is needed if the screened scenario is shown to have a CDF < 1E-08/yr with a sum less than 1E-07/yr. For these scenarios, even if containment function has failed, the LERF screening criteria have been met.
- If quantitative LERF analysis, such as that from a an internal events PRA, is available to meet the criteria above, then this analysis can be used to demonstrate LERF screening criteria have been met.
- If no detailed quantitative LERF analysis is available, then a qualitative bounding quantitative evaluation can be performed. This analysis should show that containment function will remain intact following the fire scenario, and that a LERF event given core damage is unlikely. Barriers to containment release should be reviewed to ensure that they are free of fire damage.

Qualitative evaluation of LERF should consider the characteristics of LERF given core damage, and what failures would be required. If a large early release cannot occur from the postulated combination of events, then that scenario may be qualitatively removed from further consideration. Any scenario that remains possible, no matter how unlikely, is then subjected to the quantitative screening, which can be facilitated by the use of bounding analyses in cases where the scenario would be highly unlikely. For example, a PWR large dry containment may have a low probability of LERF, even if all containment fans, coolers, spray and igniters have failed. In this case, containment isolation may be the only containment function required to be reviewed for a qualitative bounding quantitative LERF review. Another example is that of ice condenser plants which might require igniters and fans to prevent a likely LERF event. In this case, operation of the igniters and fans following the fire scenario would need to be reviewed.

Factors used in screening component combinations against the LERF criteria above should also be considered in the uncertainty evaluation discussed below.

5.3.3 UNCERTAINTY AND SENSITIVITY ANALYSIS

The intent of the screening process and associated analysis is to demonstrate with reasonable assurance that the risk from a circuit failure scenario is below the acceptance criteria described in Regulatory Guide 1.174 (Ref. 7.4.50). The decision must be based on the full understanding of the contributors to the risk and the impacts of the uncertainties, both those that are explicitly accounted for in the results and those that are not. The consideration of uncertainty is a somewhat subjective process, but the reasoning behind the decisions must be well documented. The types of uncertainty are discussed in Regulatory Guide 1.174. Guidance on what should be addressed for the screening process above is discussed below.

Comment [rhg62]: This concept of qualitative screening must parallel that in Section 5.1.1, namely in that it deals with determining whether or not specific combinations of component failures/malfunctions/etc. can lead to a large early release. Only those combinations that can do so (minimal cut sets) survive the screen, and there is no quantification in this determination. Once the qualifying combinations (minimal cut sets) have been identified, then the quantitative screening based on frequency and probability takes place. There is no qualitative screening at this point.

Comment [rhg63]: Sum of what? Scenarios leading to the same plant damage state? Scenarios with the same initiators?

Comment [rhg64]: One may consider this semantics, but in light of the distinction being drawn between qualitative and quantitative so far as two distinct steps in screening, the use of the term qualitative for anything other than the first screening step (go/no-go) should be avoided.

Comment [rhg65]: Screening based on probability is quantitative, not qualitative (see above).

Uncertainty analysis may includes include traditional parameter uncertainty, or may include and model or completeness uncertainty considerations. For scenarios involving circuit failures, parameter uncertainty can become less important than other types of uncertainty. These scenarios typically involve a single accident sequence and a limited number of cutsets. Thus the variability calculated mean value would be very close to the mean value calculated ~~using~~ usingresulting from the convolution (or simulation) of the parametric distributions would not involve many combinations, and therefore should be essentially the same as the dominant variability from the parameters within the limited number of cut sets. Model and parameter uncertainty is sometimes more effectively treated with sensitivity analysis rather than statistical uncertainty. Sensitivity analysis for this application is discussed below.

Generally, it should be possible to argue, on the basis of an understanding of the contributors to the risk, that the circuit failure scenario ~~i~~poses is an "acceptable risk" (as per Regulatory Guide 1.174). The contributors include the defense-in-depth and safety margin attributes, plus additional considerations such as spatial information, the type of cable failures required, whether the failure needs to be maintained, etc.

- The closer the scenario risk is to the acceptance criteria thresholds, the more detail is required for the assessment/screening and the uncertainty. In contrast, if the estimated risk for a scenario is small in comparison to the acceptance criteria, a simple bounding analysis may suffice with no need for detailed uncertainty analysis.

Factors to be considered in the uncertainty and sensitivity analysis include:

a) Sensitivity of the results to uncertainty of the factors in the risk equation. This includes factors such as initiating event frequency, suppression probabilities, severity factors, circuit failure probabilities, factors affecting LERF, etc.

b) Fire modeling uncertainty

c) Uncertainty of physical location of cables and equipment.

Uncertainty and sensitivity discussions should include any conservative assumptions made as a part of the analysis. For example, if fire modeling is not performed, and conservative assumptions are made about fire spread and/or damage, this should be noted.

5.4 INTEGRATED DECISION MAKING

The results of the different elements of the analysis above must be considered in an integrated manner. None of the individual analysis steps is sufficient in and of itself, and the screening of a circuit failure scenario cannot be driven solely by the numerical results of the PRA screening. They are but one input into the decision making and help build an overall picture of the implications of the circuit failures being considered. The PRA has an important role in putting the circuit failures into the proper context as it characterizes the potential impacts on the plant as a whole. The PRA screening is used to demonstrate the acceptance criteria have been satisfied. As the discussion in the previous section indicates, both qualitative and quantitative arguments may be brought to bear within their separate and distinct capacities. Even though the different pieces of the process are not combined in a formal way, they need to be formally documented.

The integrated decision process therefore includes consideration of the following:

- The screening PRA results
- Safety margins and defense-in-depth
- Uncertainty of the results.

5.4.1 DEFENSE-IN-DEPTH AND SAFETY MARGINS CONSIDERATIONS

The information in Section 5.4.4.1 is derived from Appendix A to NFPA 805, 2001 Edition, and Ref. 7.4.50. These methods should be applied to issues that are screened out either after the application of Tables 5-1 through 5-3, or after the quantitative risk significance screen in Section 5.3.

5.4.1.1 Defense-In-Depth

Defense-in-depth is defined as the principle aimed at providing a high degree of fire protection and nuclear safety. It is recognized that, independently, no one means is complete. Strengthening any means of protection can compensate for weaknesses, known or unknown, in the other items.

Balance among DID elements is a cornerstone of risk-informed applications, and is described in Ref. 7.4.50, Section 2.2.1.1. This document provides the following guidance:

- If a comprehensive risk analysis is done, it can be used to help determine the appropriate extent of defense in ~~depth~~defense-in-depth (e.g., balance among core damage prevention, containment failure, and consequence mitigation) to ensure protection of public health and safety.
- Further, the evaluation should consider the impact of the proposed licensing basis change on barriers (both preventive and mitigative) to core damage, containment failure or bypass, and balance among defense in ~~depth~~defense-in-depth attributes.

For fire protection, defense-in-depth is accomplished by achieving a balance of the following:

- Preventing fires from starting
- Detecting fires rapidly, controlling and extinguishing promptly those fires that do occur
- Providing protection for SSCs important to safety so that a fire that is not promptly extinguished by the fire suppression activities will not prevent the shutdown of the plant

For nuclear safety, defense-in-depth is accomplished by achieving a balance of the following:

- Preventing core damage
- Preventing containment failure
- Mitigating consequence

For fire protection and fire PRA, both traditional fire protection defense-in-depth (DID) and traditional nuclear safety DID are represented. Fire protection DID has been treated in the past as a balance. Fire areas with likely or potentially large or rapid-growing fires should have automatic suppression, ; areas with less likely and or smaller fires do may not have

Comment [rhg66]: Of or among what?

~~automatic~~automaticrely more on manual suppression, ; some areas may allow transient combustible storage and some do may not, etc. The DID review in this document attempts to balance both the level of traditional fire protection DID and the DID for protection of public health and safety (as measured by CDF and LERF).

Consistency with the defense-in-depth philosophy is maintained if the following acceptance guidelines, or their equivalent, are met:

1. A reasonable balance is preserved among 10 CFR 50 Appendix R DID elements in addition to prevention of core damage, prevention of containment failure, and consequence mitigation..
2. Over-reliance on, and or permitting increased length of time or risk when,-in performing programmatic activities to compensate for weaknesses in plant design is avoided.
3. Pre-fire nuclear safety system redundancy, independence, and diversity are preserved commensurate with the expected frequency and consequences of challenges to the system and uncertainties (e.g., no risk outliers). (This While this should not be construed to mean that more than one safe shutdown train must be maintained free of fire damage, it should also not be construed to mean that one such train is always adequate. A risk-informed, rather than a deterministic, approach is warranted.)
4. Independence of defense-in-depth elements is not degraded.
5. Defenses against human errors are preserved.
6. The intent of the General Design Criteria in Appendix A to 10 CFR Part 50 is maintained.

It should be noted that all elements of fire protection DID may not exist for beyond design basis fire scenarios. For example, a ~~CDP of 1.0~~ 0core damage is possible if enough fire barriers are breached (CCDP = 1). Such beyond design basis scenarios, however, should be demonstrated to be of less very low risk significance, with certainty. A very-low-risk scenario with all elements of DID in place , and a CDF of 9E-08/year would be treated differently than a scenario with a CDP of 1.0, and a CDF of 9E-08/yearwhich relies solely on a low ignition-initiating frequency for its very low risk. In the end, the balance results in consideration of all aspects of the component combination, including the risk, DID, SMsafety margin, uncertainty, and other relevant issues.

Defense-in-depth review for multiple spurious operations should consider whether the scenario affects more than one element of DID. The example above with a CCDP at or near 1.0 may be considered unacceptable if detection/suppression is ineffective. For example, if we found a scenario from a fire inside a cabinet, where suppression prior to damage to all target cables was unlikely, and the CCDP was near 1, then DID would be inadequate. In most cases, this lack of DID would correspond to a high calculated risk, since the DID elements for fire protection are integrated into the risk calculation. However, if the risk calculation relies heavily on a low fire frequency to screen the scenario, the risk calculation could screen such a scenario. The DID review would, however, not show a balance between DID and risk, and the scenario would not screen.

Applying a DID review to a screening process needs to account for conservatism in the screening. It is common to use a screening assignment of 1.0 for human error CDP or manual non-suppression probabilities during screening in order to perform the analysis with minimal resources. The DID review needs to qualitatively ~~assess~~assessweigh these factors to assure DID is maintained if a detailed quantitative assessment is not available. Additional analysis may be required to complete the DID assessment in this case, since the information available may not have been sufficient to perform a detailed quantitative assessment.

The above criteria and discussion should be used to evaluate whether defense-in-depth is maintained if a potential fire-induced circuit failure is screened out.

5.4.1.2 Safety Margins

The licensee is expected to choose the method of engineering analysis appropriate for evaluating whether sufficient safety margins would be maintained if the fire induced circuit failure were screened out. An acceptable set of guidelines for making that assessment is summarized below. Other equivalent acceptance guidelines may also be used. With sufficient safety margins (Reference 7.4.50):

- Codes and standards or their alternatives approved for use by the NRC are met.
- Safety analysis acceptance criteria in the licensing basis (e.g., FSAR, supporting analyses) are met, or proposed revisions provide sufficient margin to account for analysis and data uncertainty.

5.4.2 CORRECTIVE ACTION

If, when all evaluation phases are completed, the ΔCDF for a component or a component pair remains greater than or equal to 1E-6 per reactor year for all fire areas or the ΔCDF for a fire area remains greater than or equal to 1E-6 per reactor year for all component pairs within the fire area (summing in each case only the Screen 5 results), further analysis using detailed plant fire PRA models or actions to reduce the summed ΔCDF below 1E-6/year will be ~~evaluat~~performed to determine if the summed ΔCDF reduces below 1E-6/year (also, <1E-7/year for ΔLERF) evaluated. The complexity of possible corrective measures can be kept to a minimum by defining the additional risk reduction needed to render the ΔCDF less than 1E-7 per reactor year for any fire area (also, <1E-8/yr for ΔLERF). As an example, if a potential spurious actuation has been determined to have a ΔCDF of 1E-5 per reactor year for any fire area after completing the screening process, a corrective action that applies an additional reduction factor of at least 100 would result in an acceptable configuration (after ΔLERF considerations as well).

Comment [rhg67]: What is this? Is Section 5.2 implied?

Component combinations or fire areas that do not meet the screening criteria above should be placed within the plant's Corrective Action Program (see Section 1.1 of this document). Evaluation of the corrective action should be performed using the existing plant procedures and criteria, and using the screening analysis results as part of the evaluation. If the component combination or fire area is within the existing licensing basis, develop a compliance strategy or means of disposition to mitigate the effects due to fire damage for each component or its circuit. Any regulatory reporting should be in accordance with existing regulations.

5.4.3 Documentation

The accurate and comprehensive documentation of this assessment will be prepared and maintained as a retrievable plant record following established practices. The documentation should be maintained in accordance with existing plant procedures.

As discussed in Chapter 4 above, the documentation is referenced or included in the Fire Safe Shutdown Analysis for the area or areas affected by the MSO

5.5 PRA QUALITY

5.5.1 Applicability of the Part 3 on Internal Fire PRA of the ASME/ANS Combined PRA StandardANS FPRA Standard

Part 3 on Internal Fire PRA of The ANS Fire PRA Standard (which is being integrated into the ASME/ANS Combined PRA Standard (the "Fire Standard"), which incorporates the ANSI/ANS-58.23 Fire PRA Standard),) provides high level and supporting requirements for all steps performed in a detailed PRA used for MSO analysis. The applicability and use of the Fire Standard would depend somewhat on the Fire PRA process used, as discussed in the following sections.

Comment [rhg68]: Provide references to these standards.

In general, as greater detail is employed and conservatism removed in the process of obtaining the ~~as~~ the PRA results for an MSO approach the acceptance criteria described above, and as conservatism is removed from the analysis, the applicable capability category for the analysis can be increased. The degree to which a higher capability category may be deemed necessary to assure technical adequacy may depend on how far below the acceptance thresholds of Regulatory Guide 1.174 the results from the analysis lie. For example, if the thresholds are met with significant margin and minimal uncertainty, perhaps Capability Category 1 will suffice. If the thresholds are barely met, or the uncertainty is large, perhaps even Capability Category 3 will not suffice and a plant physical or procedural modification may be warranted for the application.

As the discussion below points out, if the screening method above is used, no capability category in the Fire Standard can be met. As more detailed Fire PRA is performed, the ~~c~~Capabilitycapability category may be Category 1 may suffice for lower risk MSOs or MSOs meeting the acceptance thresholds when analyzed using conservative PRA assumptions. Capability, or may be Category 2 or 3 may be needed for detailed Fire PRA results approaching the acceptance criteria above, or ones where the uncertainty is large. This general philosophy may not be applicable to all SRs, and a review of SRs not meeting, in general, at least Category 2 for this last example would have to include an assessment of the impact of a lower capability category on the results.

5.5.1.1 Screening Fire PRA

If an MSO or group of MSOs is screened using the preliminary screening method as described in Sections 5.2 above, the Fire Standard requirements do not apply. The method is generally conservative, and review against the standard would result in a "not met" assessment for many of the supporting requirements.

5.5.1.2 Focused Scope Fire PRA

If the Fire SDP or NUREG/CR-6850 is used to analyze the MSO, then the applicable supporting requirements of the standard can must be reviewed against the analysis. However, many of the Fire Standard SRs are not applicable to a Focused-Scope Fire PRA, since the focused scope analyzes the fire features related to the MSO alone, and not associated with the whole plant or whole room risk estimate. For example, if none of the MSO analysis involved Hydrogen Fires, Bus Duct Fires, Reactor Coolant Pump Fires, etc., then the various SRs related to these fires or areas containing these fires may not need to be reviewed for the MSO analysis.

For a Focused-Scope Fire PRA, only the applicable SRs would need to be reviewed in support of the MSO analysis. Additionally, SRs that are reviewed may not be applied in a similar level of detail as a full Fire PRA. For example, non-suppression analyzed for an individual scenario would be reviewed against the applicable SRs. However, the SRs may be applicable to many other possible scenarios not associated with the MSOs. The review of the SR would be limited to the application, and as a result, the associated grade for the SR would only be assigned for the limited scope review. As a result, the Peer Review scope would need to be specified and documented as a part of the overall MSO documentation process. This includes both the scope of the SRs reviewed or not reviewed and the limitations or scope of each of the reviewed SRs.

Caution must be exercised before dismissing any SRs as outside the analytical bounds of the Focused Score Fire PRA. Experience has shown that there are often subtle dependencies among seemingly unrelated elements of a full-scope PRA that could be erroneously dismissed *a priori* when setting the analytical bounds for the Focused Scope version.

5.5.1.3 Full Fire PRA

If a full Fire PRA is performed, and the MSO scenario analysis is included in the full Fire PRA, then all of the Fire PRA Standard SRs would apply. As with any application, SRs where a requirement is not met or Category I is assessed would need to be documented as a part of the MSO analysis, demonstrating the associated F&~~O~~OFinding does not affect the analysis results.

5.5.2 Peer Review of the Focused-Scope or Full Fire PRA

A peer review of the focused-scope Fire PRA is required once the initial screening of MSOs is complete. The peer review will may differ considerably from a peer review of a complete Fire PRA in the following aspects:

1) The focused-scope Fire PRA will contain screening analysis as described above, which is not designed to meet the Fire PRA standard Standard Supporting Requirements. The screening analysis is not reviewed against any of the Fire PRA Standard SRs (such would be deemed as "not met").

2) The detailed Fire PRA for MSO scenarios is an analysis of the MSO scenarios only, and would may not provide a Fire PRA for a Fire Area or Compartment. As such, the Fire PRA would only apply specific Fire PRA steps needed to show the MSO risk is low. The corresponding Fire PRA standard Standard requirements for the applied steps would be applicable for the peer review, but other steps would may not need to be reviewed. Additionally, many of the SRs reviewed would only be applicable to the MSOs analyzed, and not to the entire plant. Of course, the previous caution must be kept in mind.

Prior to the performance of a peer review against a Focused-Scope Fire PRA, the expected scope should be documented by a pre-review of the MSO analysis results. This scope would then be used to determine the number and capability of the Fire PRA Peer Review Team. Upon completion of the peer review, the limitations of the review for each SR should also be specified in the documentation.

6 DEFINITIONS

The following definitions are consistent with NRC-recognized definitions.

The numbers in brackets [ ] refer to the IEEE Standards in which the definitions are used. Refer to Section 2 of IEEE Standard 380-1975 for full titles.

Those definitions without a specific reference are consistent with those specified in reference 7.4.32.

Important to Safe Shutdown (Previously called Associated circuits) of concern

Generic Letter 81-12 – Those cables (safety related, non-safety related, Class 1E, and non-Class 1E) that have a physical separation less than that required by Appendix R Section III.G.2 and have one of the following:

> **Common Power Source**
>
> A common power source with the shutdown equipment (redundant or alternative) and the power source is not electrically protected from the circuit of concern by coordinated breakers, fuses, or similar devices, or
>
> **Spurious Operation**
>
> A connection to circuits of equipment whose spurious operation would adversely affect the shutdown capability (e.g., Residual Heat Removal/Reactor Coolant System isolation valves, Automatic Depressurization System valves, Pressure-Operated Relief Valves, steam generator atmospheric valves, instrumentation, steam bypass, etc.), or
>
> **Common Enclosure**
>
> A common enclosure (e.g., raceway, panel, junction, etc.) with the shutdown cables (redundant or alternative), and are not electrically protected by circuit breakers, fuses or similar devices, or will allow the propagation of the fire into the common enclosure.

Cable

IEEE Standard 100-1984 – A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable) or a combination of conductors insulated from one another (multiple-conductor cable). [391]

Circuit

IEEE Standard 100-1984 – A conductor or system of conductors through which an electric current is intended to flow. [391]

Circuit failure modes

The following are the circuit failure modes that are postulated in the post-fire safe shutdown analysis as a result of a fire:

Hot Short

A fire-induced insulation breakdown between conductors of the same cable, a different cable or from some other external source resulting in a compatible but undesired impressed voltage or signal on a specific conductor.

Open Circuit

A fire-induced break in a conductor resulting in a loss of circuit continuity.

Short-to-Ground

A fire-induced breakdown of a cable's insulation system resulting in the potential on the conductor being applied to ground/neutral.

Cold Shutdown Repair

Repairs made to fire damaged equipment required to support achieving or maintaining cold shutdown for the required safe shutdown path.

Conductor

IEEE Standard 100-1984 – A substance or body that allows a current of electricity to pass continuously along it. [210, 244, 63] *Clarification:* a single "wire" within a cable; conductors could also be considered a circuit or a cable.

Design Basis Fire

A postulated event used in the post-fire safe shutdown analysis. See Exposure Fire.

Emergency Control Station

Location outside the main control room where actions are taken by operations personnel to manipulate plant systems and controls to achieve safe shutdown of the reactor. [NRC RIS 2005-30]

Comment [h69]: This definition should be made consistent with Draft RG 1.205.

Enclosure

IEEE Standard 380-1975 – An identifiable housing such as a cubicle, compartment, terminal box, panel, or enclosed raceway used for electrical equipment or cables. [384]

Exposure Fire

SRP Section 9.5.1 – 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

Generic Letter 86-10 – The term "fire area" as used in Appendix R means an area sufficiently bounded to withstand the hazards associated with the fire area and, as necessary, to protect important equipment within the fire area from a fire outside the area.

In order to meet the regulation, fire area boundaries need not be completely sealed with floor to ceiling and/or wall-to-wall boundaries. Where fire area boundaries were not approved under the Appendix A process, or where such boundaries are not wall-to-wall or floor-to-ceiling boundaries with all penetrations sealed to the fire rating required of the boundaries, licensees must perform an evaluation to assess the adequacy of fire area boundaries in their plants to determine if the boundaries will withstand the hazards associated with the area and protect important equipment within the area from a fire outside the area.

Fire Barrier

SRP Section 9.5. – 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 Frequency (F_f)

The frequency of fires with a potential to damage critical equipment if left alone.

Fire Protection Design Change Evaluation

The process replacing the 50.59 evaluation process (described in NEI 02-03) that is used by a licensee to document compliance with the fire protection license condition to assure that changes to the approved fire protection program do not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire.

Fire Protection Program

10 CFR 50, Appendix R, Section II.A – the fire protection policy for the protection of structures, systems, and components important to safety at each plant and the procedures, equipment, and personnel required to implement the program at the plant site. The fire protection program shall extend the concept of defense-in-depth to fire protection in fire areas important to safety, with the following objectives:

- Prevent fires from starting.
- Rapidly detect, control, and promptly extinguish those fires that do occur.
- 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.

Fire Zone

The subdivision of fire area(s) for analysis purposes that is not necessarily bound by fire-rated barriers.

Free of Fire Damage

It is expected that the term "free of fire damage" will be further clarified in a forthcoming Regulatory Issue Summary. Until this occurs, NRC recommends using the following guidance in Regulatory Guide 1.189:

"The structure, system, or component under consideration is capable of performing its intended function during and after the postulated fire, as needed, without repair."

Generic Letter 86-10 Fire Hazards Evaluation

A technical engineering evaluation used to evaluate equivalency of fire protection features to those required by the regulations or to evaluate fire protection features that are commensurate with the potential fire hazard. For plants licensed prior to 1979, these evaluations may form the basis for an Appendix R exemption request or support a plant change evaluation using accepted regulatory processes. For plants licensed after January 1, 1979, these evaluations may be used in conjunction with a fire protection design change evaluation to alter the current licensing basis or they may be submitted to the NRC for review and acceptance as a deviation request. (Note: Previously approved deviation requests may be altered using a fire protection design change evaluation without re-submittal to the NRC.)

High Impedance Fault

Generic Letter 86-10 – electrical fault below the trip point for a breaker on an individual circuit. See "Multiple High Impedance Fault."

High/Low Pressure Interface

Refer to Appendix C to this document.

Hot Short

See "Circuit failure modes."

Important to Safe Shutdown (SSD)

10 CFR 50, Appendix R, Section III.G.1 describes Structures, Systems and Components (SSC) important to safe shutdown for which fire protection features apply. Components classified as important to SSD in accordance with Appendix H may apply different mitigation tools than components classified as required for hot shutdown.

Isolation Device

IEEE Standard 380-1975 – A device in a circuit that prevents malfunctions in one section of a circuit from causing unacceptable influences in other sections of the circuit or other circuits. [384]

Local Operation

Operation of safe shutdown equipment by an operator outside the Main Control Room when automatic, remote manual, or manual operation are no longer available (e.g. opening of a motor operated valve using the hand wheel).

Operator Manual Action

Action performed by operators to manipulate components and equipment from outside the main control room to achieve and maintain post-fire hot shutdown, not including "repairs."

Multiple High Impedance Fault(s)

A condition where multiple circuits fed from a single power distribution source each have a high impedance fault. See Appendix B.1.

Open Circuit

See 'Circuit Failure Modes'.

Probability of Spurious Actuation (P_{SA})

The probability of undesirable spurious operation(s) of the component, or of component being potentially impacted by the fire-induced circuit failure.

Raceway

IEEE Standard 380-1975 – Any channel that is designed and used expressly for supporting wires, cable, or busbars. Raceways consist primarily of, but are not restricted to, cable trays, conduits, and interlocked armor enclosing cable. [384]

Remote Control

Plant design features that allow the operation of equipment through a combination of electrically powered control switches and relays. Remote control can typically be performed from the control room or from local control stations, including the remote shutdown panel and other locations with control capability outside the control room.

Remote Manual Operation

Operation of safe shutdown equipment on the required safe shutdown path using remote controls (e.g., control switches) specifically designed for this purpose from a location other than the main control room.

Remote Shutdown Location

A plant location outside the control room with remote control capability for shutdown.

Remote Shutdown Panel

The panel included within the plant design for the purpose of satisfying the requirements of 10 CFR 50 Appendix A General Design Criterion 19. If electrical isolation and redundant fusing are provided at this location, it may also be suitable for use in achieving and maintaining safe shutdown for an event such as a control room fire.

Comment [h70]: This implies that Remote Shutdown is consistently used for the GDC 19 panel; Many plants call the GDC 19 panel the Auxiliary Control Panel or Auxiliary Shutdown Panel.

Repair Activity

Those actions required to restore operation to post-fire safe shutdown equipment that has failed as a result of fire-induced damage. Repairs may include installation, removal, assembly, disassembly, or replacement of components or jumpers using materials, tools, procedures, and personnel available on site (e.g., replacement of fuses, installation of temporary cables or power supplies, installation of air jumpers, the use of temporary ventilation). Credit for repair activities for post-fire safe shutdown may only be taken for equipment required to achieve and maintain cold shutdown. Repairs may require additional, more detailed instructions, including tools to be used, sketches, and step-by-step instructions for the tasks to be performed. Repair activities are intended to restore functions and not equipment since the equipment may be destroyed in a fire event. Repair activities may rely on exterior security lighting or portable lighting if independent 8-hour battery backed lighting is unavailable.

Required Safe Shutdown Path

The safe shutdown path selected for achieving and maintaining safe shutdown in a particular fire area. This safe shutdown path must be capable of performing all of the required safe shutdown functions described in this document.

Required Safe Shutdown System

A system that performs one or more of the required safe shutdown functions and is, therefore, a part of the required safe shutdown path for a particular fire area.

Required Hot Shutdown Component

Equipment that is required to either function or not malfunction so that the required safe shutdown path will be capable of achieving and maintaining hot shutdown in a particular fire area and meet the established regulatory criteria.

Required Hot Shutdown Cable/Circuit

Cable/circuit required to support the operation or prevent the mal-operation of required hot shutdown component in a particular fire area.

Safe Shutdown

[Reference 7.4.38] A shutdown with (1) the reactivity of the reactor kept to a margin below criticality consistent with technical specifications, (2) the core decay heat being removed at a controlled rate sufficient to prevent core or reactor coolant system thermal design limits from being exceeded, (3) components and systems necessary to maintain these conditions operating within their design limits, and (4) components and systems necessary to keep doses within prescribed limits operating properly.

[Reference 7.4.14] For fire events, those plant conditions specified in the plant Technical Specifications as Hot Standby, Hot Shutdown, or Cold Shutdown.

For those plants adopting NFPA 805, the term "safe shutdown" is not explicitly defined. Please refer to the discussion of "Nuclear Safety Performance Criteria" in NFPA 805 for more information about performance criteria that, if met, provide reasonable assurance in the event of a fire that the plant is not placed in an unrecoverable condition.

Safe Shutdown Capability

Redundant

Any combination of equipment and systems with the capability to perform the shutdown functions of reactivity control, inventory control, decay heat removal, process monitoring and associated support functions when used within the capabilities of its design.

Alternative

For a given fire area/zone where none of the redundant safe shutdown capability are "free of fire damage" and dedicated equipment is not provided, the shutdown strategy used is classified as alternative.

Dedicated

A system or set of equipment specifically installed to provide one or more of the post-fire safe shutdown functions of inventory control, reactivity control, decay heat removal, process monitoring, and support as a separate train or path.

Safe Shutdown Equipment/Component

Equipment that performs a function that is required for safe shutdown either by operating or by not mal-operating.

Short-to-Ground

See "Circuit Failure Modes."

Spurious Operation

The possible inadvertent operation or repositioning of a piece of equipment.

7 REFERENCES

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7.1.2 80-48: Proposed Rule Fire Protection Program for Nuclear Power Plants

7.1.3 80-56: Memorandum and Order RE: Union of Concerned Scientists Petition

7.1.4 80-100: Resolution of Fire Protection Open Items

7.1.5 81-12: Fire Protection Rule, dated February 20, 1981

7.1.6 81-12: Clarification of Generic Letter 81-12, Letter from the NRC to PSE&G, dated April 20, 1982, Fire Protection Rule - 10 CFR 50.48(c) - Alternate Safe Shutdown - Section III.G.3 of Appendix R to 10 CFR 50

7.1.7 82-21: Tech Specs for Fire Protection Audits

7.1.8 83-33: NRC Positions on Appendix R

7.1.9 85-01: Fire Protection Policy Steering Committee Report

7.1.10 86-10: Implementation of Fire Protection Requirements, dated April 24, 1986

7.1.11 86-10: Supplement 1 to Generic Letter, Implementation of Fire Protection Requirements

7.1.12 88-12: Removal of Fire Protection Requirements from Tech Specs

7.1.13 88-20: Supplement 4 IPEEE

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7.1.15 92-08: Thermo-Lag Fire Barriers

7.1.16 93-06: Use of Combustible Gases in Vital Areas

7.1.17 95-01: Fire Protection for Fuel Cycle Facilities

7.2 BULLETINS

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7.2.2 77-08: Assurance of Safety

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7.3.3 83-69: Improperly Installed Fire Dampers

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7.3.6 84-16: Failure of Automatic Sprinkler System Valves to Operate

7.3.7 84-92: Cracking of Flywheels on Fire Pump Diesel Engines

7.3.8 85-09: Isolation Transfer Switches and Post-fire Shutdown Capability, January 31, 1985

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7.3.11 86-35: Fire in Compressible Material

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7.3.15 86-106: Supplement 3 Surry Feedwater Line Break

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7.3.17 87-49: Deficiencies in Outside Containment Flooding Protection

7.3.18 87-50: Potential LOCA at High and Low Pressure Interfaces from Fire Damage, October 9, 1987

7.3.19 88-04: Inadequate Qualification of Fire Barrier Penetration Seals

7.3.20 88-04: Supplement 1 Inadequate Qualification of Fire Barrier Penetration Seals

7.3.21 88-05: Fire in Annunciator Control Cabinets

7.3.22 88-45: Problems in Protective Relay and Circuit Breaker Coordination, July 7, 1988

7.3.23 88-56: Silicone Fire Barrier Penetration Seals

7.3.24 88-60: Inadequate Design & Installation of Watertight Penetration Seals

7.3.25 88-64: Reporting Fires in Process Systems

7.3.26 89-52: Fire Damper Operational Problems

7.3.27 90-69: Adequacy of Emergency and Essential Lighting, October 31, 1990

7.3.28 91-17: Fire Safety of Temporary Installations

7.3.29 91-18: Resolution of Degraded & Nonconforming Conditions

7.3.30 91-37: Compressed Gas Cylinder Missile Hazards

7.3.31 91-47: Failure of Thermo-Lag

7.3.32 91-53: Failure of Remote Shutdown Instrumentation

7.3.33 91-77: Shift Staffing at Nuclear Power Plants

7.3.34 91-79: Deficiencies in Installing Thermo-Lag

7.3.35 91-79: Supplement 1

7.3.36 92-14: Uranium Oxide Fires

7.3.37 92-18: Loss of Remote Shutdown Capability During a Fire, February 28, 1992

7.3.38 92-28: Inadequate Fire Suppression System Testing

7.3.39 92-46: Thermo-Lag Fire Barrier Special Review Team Final Report

7.3.40 92-55: Thermo-Lag Fire Endurance Test Results

7.3.41 92-82: Thermo-Lag Combustibility Testing

7.3.42 93-40: Thermal Ceramics Fire Endurance Tests

7.3.43 93-41: Fire Endurance Tests - Kaowool, Interam

7.3.44 93-71: Fire at Chernobyl Unit 2

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7.3.49 94-31: Failure of Wilco Lexan Fire Hose Nozzles

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7.3.52 94-86: Legal Actions Against Thermal Science Inc.

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7.3.57 95-36: Problems with Post-Fire Emergency Lighting

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7.3.72 97-73: Fire Hazard in the Use of a Leak Sealant

7.3.73 97-82: Inadvertent Control Room Halon Actuation

7.4 OTHER RELATED DOCUMENTS

7.4.1 10 CFR 50.48 Fire Protection (45 FR 76602)

7.4.2 10 CFR 50 Appendix A GDC 3 Fire Protection

7.4.3 10 CFR 50 Appendix R Fire Protection for Operating Nuclear Power Plants

7.4.4 Branch Technical Position APCSB 9.5-1 Guidelines for Fire Protection

7.4.5 Appendix A to Branch Tech Position 9.5-1 Guidelines for Fire Protection

7.4.6 NUREG-0800 9.5.1 Fire Protection Program

7.4.7 NRC Insp. Procedure 64100 Postfire Safe Shutdown, Emergency Lighting, Oil Collection

7.4.8 NRC Insp. Procedure 64150 Triennial Postfire Safe Shutdown Capability

7.4.9 NRC Insp. Procedure 64704 Fire Protection Program

7.4.10 NUREG/BR-0195 Enforcement Guidance

7.4.11 NUREG-75/087 Standard Review Plan (No revision level listed)

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7.4.13 NUREG-75/087 Standard Review Plan, Rev. 2

7.4.14 Reg Guide 1.120 Fire Protection Guidelines for Nuclear Power Plants

7.4.15 Reg Guide 1.120 Rev. 1, Fire Protection Guidelines for Nuclear Power Plants

7.4.16 Reg Guide 1.189 Fire Protection for Operating Nuclear Power Plants

7.4.17 NUREG-0654 Criteria for Preparation of Emergency Response Plans

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7.4.19 SECY-82-13B (4/21/82) Fire Protection Schedules and Exemptions

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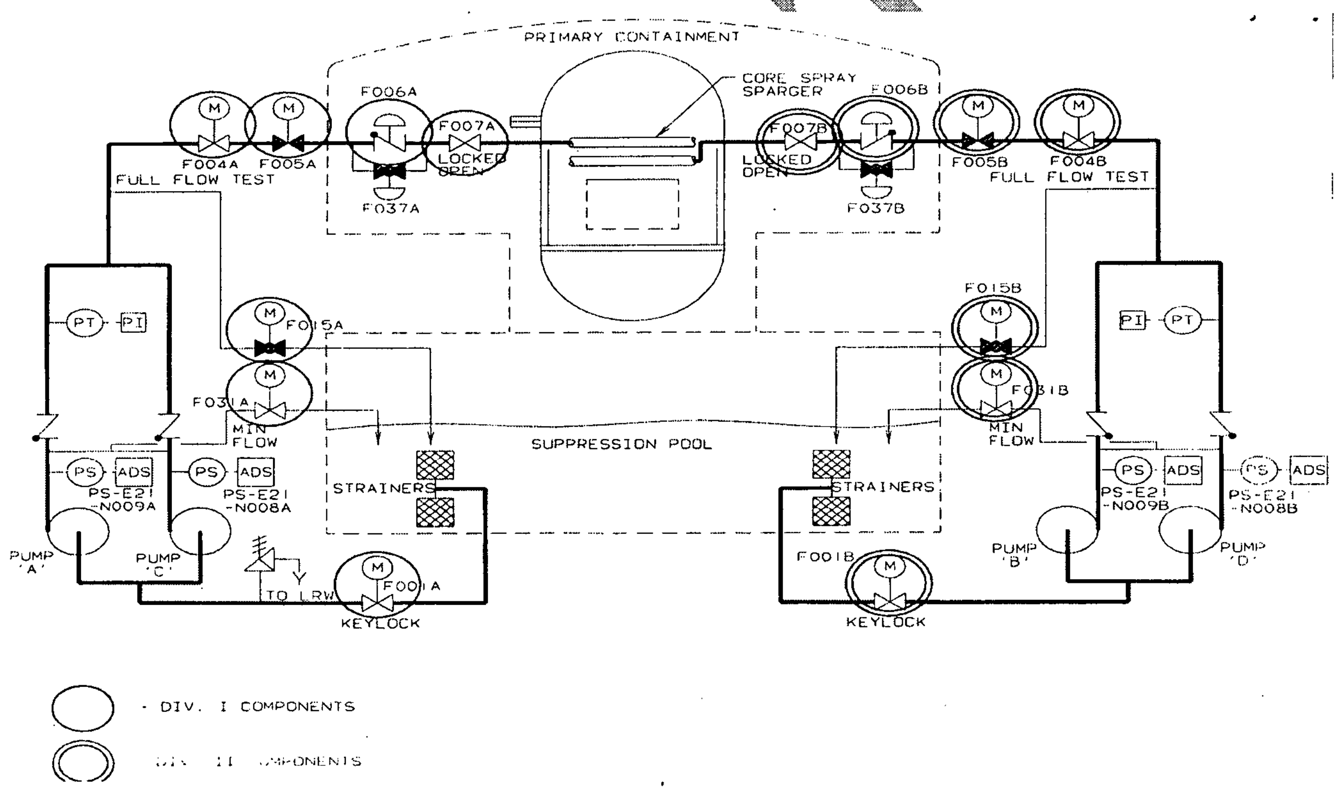
ATTACHMENT 1
EXAMPLE OF TYPICAL BWR SAFE SHUTDOWN PATH DEVELOPMENT

Safe Shutdown Path 1	Safe Shutdown Path 2	Safe Shutdown Path 3
Reactivity Control	***Reactivity Control***	***Reactivity Control***
CRD (Scram Function) Manual Scram and/or Operator Manual Action to remove RPS Power or to vent the instrument air header	CRD (Scram Function) Manual Scram and/or Operator Manual Action to remove RPS Power or to vent the instrument air header	CRD (Scram Function) Manual Scram and/or Operator Manual Action to remove RPS Power or to vent the instrument air header
Pressure Control	***Pressure Control***	***Pressure Control***
Manual ADS/SRVs using available Control Room and Remote Switches	SRVs using the available Remote Shutdown Panel and Remote Switches	Manual ADS/SRVs using available Control Room and Remote Switches
Inventory Control	***Inventory Control***	***Inventory Control***
Core Spray	RCIC RHR LPCI	RHR LPCI
Decay Heat Removal	***Decay Heat Removal***	***Decay Heat Removal***
RHR Supp. Pool Cooling Mode Service Water Core Spray, Alt. SDC Mode	RHR Supp. Pool Cooling Mode Service Water RHR Shutdown Cooling Mode	RHR Supp. Pool Cooling Mode Service Water RHR, Alt. SDC Mode
Process Monitoring	***Process Monitoring***	***Process Monitoring***
Supp. Pool Monitoring Nuc. Boiler Instru.	Supp. Pool Monitoring Nuc. Boiler Instru.	Supp. Pool Monitoring Nuc. Boiler Instru.
Associated Support Functions	***Associated Support Functions***	***Associated Support Function***
Cooling Systems	***Cooling Systems***	***Cooling Systems***
RHR Room Coolers Service Water Pumphouse HVAC EDG HVAC	RHR Room Coolers RCIC Room Coolers Service Water Pumphouse HVAC EDG HVAC	RHR Room Coolers Service Water Pumphouse HVAC EDG HVAC
Electrical	***Electrical***	***Electrical***
EDGs or Offsite Power Electrical Distribution Equipment	EDGs or Offsite Power Electrical Distribution Equipment	EDGs or Offsite Power Electrical Distribution Equipment

ATTACHMENT 2
ANNOTATED P&ID ILLUSTRATING SSD SYSTEM PATHS [BWR EXAMPLE]

Comment [RFR71]: Shouldn't the pumps be circled also? Also, should the bypass valves F037A and F037B be circled – could their spurious opening prevent SSD?



ATTACHMENT 3
EXAMPLE OF SAFE SHUTDOWN EQUIPMENT LIST

(Sorted by Equipment ID)

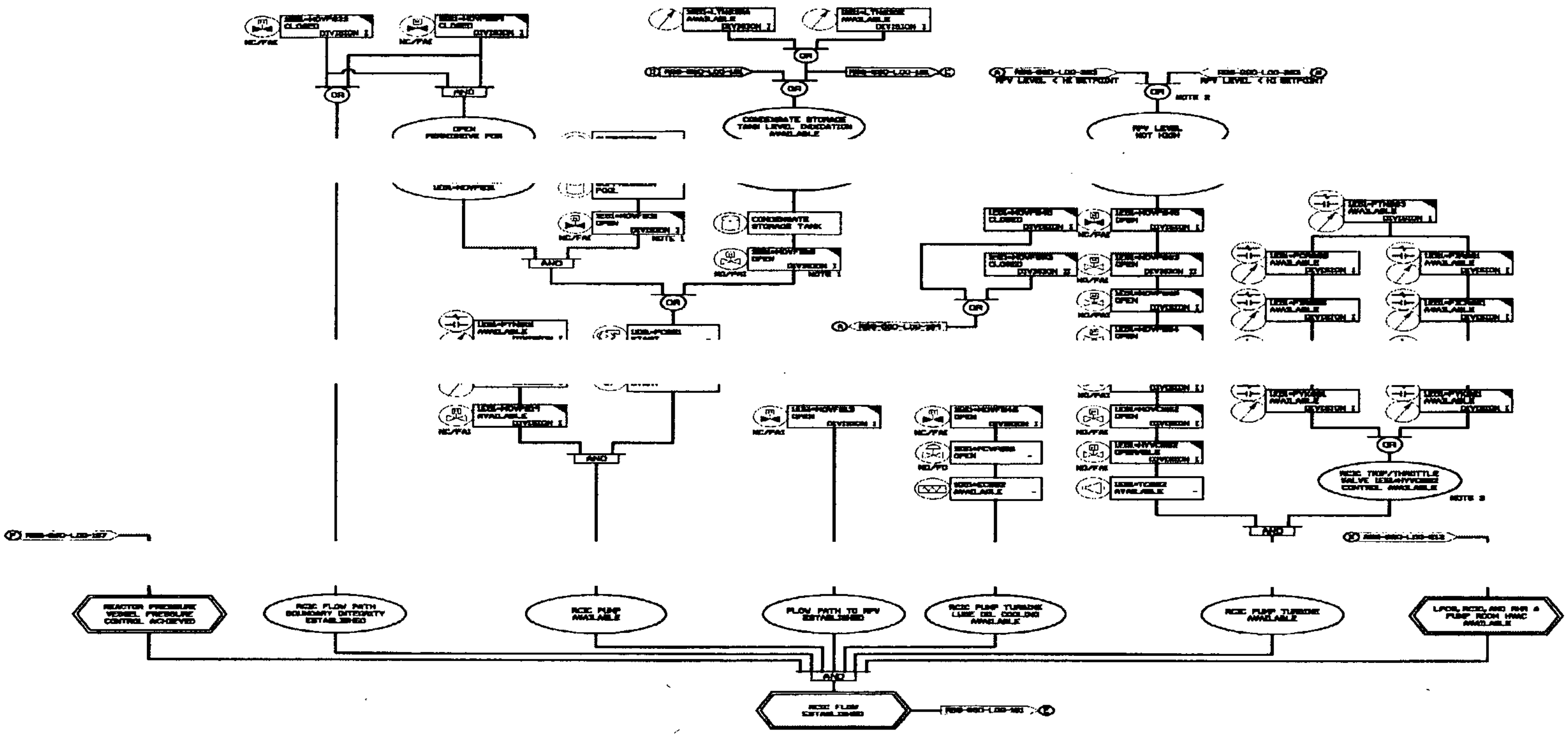
Equipment ID	Logic Diagram	System	Unit	Equipment Type	SSD Path	Equipment Description	Equip FA	Normal Mode	Shutdown Mode(s)	High/ Low	Air Fail	Power Fail	Reference

Attachment 3
(Continued)

A description of the Safe Shutdown Equipment List column headings is provided as follows:

Equipment ID	Identifies the equipment/component ID No. from the P&ID or one line diagram.
Logic Diagram	Identifies a safe shutdown logic diagram reference that may illustrate the relationship between the equipment and other system components
System	Identifies the Appendix ~~RRR~~post-fire safe shutdown System of which the equipment is part.
Unit	Identifies the Unit(s) that the equipment supports.
Equipment Type	Identifies the type of equipment (e.g., MOV, pump, SOV).
SSD Path	Identifies the safe shutdown path(s) for which the equipment is necessary to remain functional or not mal-operate.
Equipment Description	Provides a brief description of the equipment.
Equip FA	Identifies the fire area where the equipment is located.
Normal Mode	Identifies the position or mode of operation of the equipment during normal plant operation.
Shutdown Mode(s)	Identifies the position or mode of operation of the equipment during shutdown conditions.
High/Low	Identifies whether the equipment is considered part of a high/low pressure interface.
Air Fail	If applicable, identifies the position of equipment resulting from a loss of air supply.
Power Fail	Identifies the position of equipment resulting from a loss of electrical power.
Reference	Identifies a primary reference drawing (P&ID or electrical) on which the equipment can be found.

ATTACHMENT 4
SAFE SHUTDOWN LOGIC DIAGRAM [BWR EXAMPLE]



ATTACHMENT 5
EXAMPLE OF AFFECTED EQUIPMENT REPORT

(Sorted by Fire Area, System, Unit & Equipment ID)

Comment [RFR72]: Shouldn't the list also be sorted by SSD path?

Fire Area:			Required Path(s):			FA Description:				Suppression:			Detection:	
System	**Unit**	**Logic Diagram**	**Equipment ID**	**Equip Type**	**SSD Path**	**Equip FA**	**Equipment Description**	**Normal Mode**	**Shutdown Mode(s)**	**High/ Low**	**Air Fail**	**Power Fail**	**Disp Code**	**Compliance Strategy**

Attachment 5
(Continued)

A description of the Affected Equipment Report column headings is provided as follows:

Fire Area	Identifies the fire area where the equipment or cables are located.
Required Path(s)	Identifies the safe shutdown path(s) relied upon to achieve safe shutdown in the fire area.
FA Description	Provides a brief description of the fire area.
Suppression	Identifies the type of fire suppression (e.g. manual, auto, none) within the fire area.
Detection	Identifies the type of fire detection within the fire area.
System	Identifies the Appendix ~~RRR~~post-fire safe shutdown System of which the equipment is part.
Unit	Identifies the Unit(s) that the equipment supports.
Logic Diagram	Identifies a safe shutdown logic diagram reference that may illustrate the relationship between the equipment and other system components
Equipment ID	Identifies the equipment/component ID No. from the P&ID or one line diagram.
Equip Type	Identifies the type of equipment (e.g. MOV, pump, SOV).
SSD Path	Identifies the safe shutdown path(s) for which the equipment is necessary to remain functional or not mal-operate.
Equip FA	Identifies the fire area where the equipment is located.
Equipment Description	Provides a brief description of the equipment.
Normal Mode	Identifies the position or mode of operation of the equipment during normal plant operation.
Shutdown Mode(s)	Identifies the position or mode of operation of the equipment during shutdown conditions.
High/Low	Identifies whether the equipment is considered part of a high/low pressure interface.
Air Fail	If applicable, identifies the position of equipment resulting from a loss of air supply.
Power Fail	Identifies the position of equipment resulting from a loss of electrical power.
Disp Code	A code that corresponds to specific compliance strategies and enables sorting and grouping of data.
Compliance Strategy	A brief discussion of the method by which the equipment is resolved to meet Appendix R compliance.

ATTACHMENT 6
EXAMPLE OF FIRE AREA ASSESSMENT REPORT

(Sorted by Fire Area, System, Unit & Equipment ID)

Comment [RFR73]: SSD Path??

Fire Area:			**Required Path(s):**			**System:**					**Unit:**			
Equipment ID	Logic Diagram	Equip Type	SSD Path	Equip FA	Equipment Description	Normal Mode	Shutdown Mode(s)	High// Low	Air Fail	Power Fail	Cable	Cable Funct	Disp Code	Compliance Strategy

Attachment 6
(Continued)

A description of the Fire Area Assessment Report column headings is provided as follows:

Fire Area	Identifies the fire area where the cables or equipment are located.
Required Path(s)	Identifies the safe shutdown path(s) relied upon to achieve safe shutdown in the fire area.
System	Identifies the Appendix R System of which the equipment is part.
Unit	Identifies the unit(s) that the equipment supports.
Equipment ID	Identifies the equipment/component ID No. from the P&ID or one line diagram.
Logic Diagram	Identifies a safe shutdown logic diagram reference that may illustrate the relationship between the equipment and other system components
Equip Type	Identifies the type of equipment (e.g. MOV, pump, SOV).
FA Description	Provides a brief description of the fire area.
Suppression	Identifies the type of fire suppression (e.g. manual, auto, none) within the fire area.
Detection	Identifies the type of fire detection within the fire area.
Equip Type	Identifies the type of equipment (e.g. MOV, pump, SOV).
SSD Path	Identifies the safe shutdown path(s) for which the equipment is necessary to remain functional or not maloperate.
Equip FA	Identifies the fire area where the equipment is located.
Equipment Description	Provides a brief description of the equipment.
Normal Mode	Identifies the position or mode of operation of the equipment during normal plant operation.
Shutdown Mode(s)	Identifies the position or mode of operation of the equipment during shutdown conditions.
High/Low	Identifies whether the equipment is considered part of a high/low pressure interface.
Air Fail	If applicable, identifies the position of equipment resulting from a loss of air supply.
Power Fail	Identifies the position of equipment resulting from a loss of electrical power.
Cable	Identifies the safe shutdown cable located in the fire area.
Cable Funct	Identifies the function of the cable (e.g., power, control) and whether its failure can result in a spurious operation.
Disp Code	A code that corresponds to a specific compliance strategy and enables sorting and grouping of data.
Compliance Strategy	A brief discussion of the method by which the cable is resolved to meet Appendix R compliance.