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Methodology for Low Power/Shutdown Fire PRA

Draft Report for Comment

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Abstract

This document presents a probabilistic risk assessment (PRA) method for quantitatively analyzing fire risk in commercial nuclear power plants during low power and shutdown (LPSD) conditions, including the determination of core damage frequency (CDF) and large early release frequency (LERF). Future updates will be made to this document as experience is gained with LPSD quantitative risk analyses of both internal events and fires.

This LPSD fire PRA method is intended to be used in combination with an at-power fire PRA performed using the method documented in Nuclear Regulatory Commission (NRC) Office of Nuclear Regulatory Research (RES) publication NUREG/CR-6850 and Electric Power Research Institute (EPRI) publication TR-1011989, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities." This LPSD fire PRA method directly parallels that at-power fire PRA method with respect to the structure and objectives of its technical analysis tasks, addressing those aspects of the at-power fire PRA that require unique treatment in the context of low-power or shutdown conditions. This LPSD fire method also requires an LPSD internal events PRA; that is, both the at-power fire PRA and the LPSD internal events PRA are needed as starting points for conducting an LPSD fire PRA using the method described in this document.

The NRC developed this LPSD fire quantitative risk method so analysts would be able to use a quantitative approach for estimating fire risk during LPSD conditions. While current LPSD safety analyses for fires under National Fire Protection Association Standard 805 (NFPA 805) focus on qualitative, defense-in-depth methods, it is envisioned that applications in the future may evolve to be more quantitative. At present, this method can provide an alternative for the analysis of LPSD fire risk in situations where qualitative methods are not appropriate, or where activities such as planning for an outage could benefit from risk reduction insights that could be gained from a quantitative analysis. It could also prove essential for the analysis of situations involving unusual, complex plant operating states (POSs).

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In contrast, fire PRAs for Low Power and Shutdown (LPSD) conditions have been conducted in only a few cases and all of the known analyses were based on methods and data that pre-date the RES/EPRI full-power fire PRA method. Methods for conducting such studies have not previously seen the same level of development as have the full-power methods and no comprehensive source for analysis guidance compatible with the current state-of-the art fire risk methods (e.g., [1]) is known to exist prior to this document. The LPSD fire PRA methodology presented here is presented as an extension of, or supplement to, the RES/EPRI full-power fire PRA method. That is, the LPSD method relies extensively on the extension of full-power analysis methods to LPSD conditions. As a result, documentation of the methodology as presented here focuses on those elements where the full-power methods should be adapted or extended to address LPSD conditions.

LPSD plant operating states (POSs) potentially include a broad range of conditions for power, temperature and pressure levels. This methodology assumes that LPSD PRA might include plant operations at roughly the 30% power level and lower; hence, the LPSD conditions encompass a very broad spectrum of potential operating conditions.

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Abbreviations and Acronyms

ADAMS	Agency-wide Documents Access and Management System
ANS	American Nuclear Society
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BWR	Boiling Water Reactor
CCDP	Conditional Core Damage Probability
CDF	Core Damage Frequency
CFR	Code of Federal Regulations
CLERP	Conditional Large Early Release Probability
dc	Direct current
EOP	Emergency Operating Procedure
EPRI	Electric Power Research Institute
FAQ	Frequently Asked Question
FEDB	Fire Events Database
FEP	Fire Emergency Procedure
HEAF	High Energy Arcing Fault
HEP	Human Error Probability
HFE	Human Failure Event
HRA	Human Reliability Analysis
HRR	Heat Release Rate
ICDP	Incremental Core Damage Probability
ID	Identifier
ILERP	Incremental Large Early Release Probability
IS	Ignition Source
LCO	Limiting Condition of Operation
LERF	Large Early Release Frequency
LOCA	Loss of Coolant Accident
LPSD	Low Power and Shutdown
MCB	Main Control Board
MCR	Main Control Room
MG	Motor-Generator
NFPA	National Fire Protection Association
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
PAU	Physical Analysis Unit
POS	Plant Operating State
PRA	Probabilistic Risk Assessment
PWR	Pressurized Water Reactor
RCP	Reactor Coolant Pump
RES	The Office of Nuclear Regulatory Research (at NRC)
RG	Regulatory Guide
RISC	Risk Informed Standards Committee
RPS	Reactor Protection System
SRV	Safety Relief Valve
T/G	Turbine/Generator
ZOI	Zone of Influence

1 Introduction

1.1 Introduction and Purpose

Methods for the application of Probabilistic Risk Assessment (PRA) to internal fire events during full-power operation of Nuclear Power Plants (NPPs) have evolved based on an extensive development process that began in the 1970s. Recently, existing fire PRA methods and evolutionary advances were consolidated through a collaborative effort between the U.S. Nuclear Regulatory Commission (NRC) Office of Nuclear Regulatory Research (RES) and the Electric Power Research Institute (EPRI). This work led to publication, in 2005, of the *EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities* [1] (referred to in this document more simply as either "the RES/EPRI full-power fire PRA method" or "reference [1]"). Even these most recent fire PRA methods continue to evolve based on their application by industry and on the communication of lessons learned to both industry and the NRC. Many of the currently operating U.S. NPPs are actively engaged in the conduct of fire PRAs driven, in part, by licensee decisions to transition to the alternative risk-informed, performance-based fire protection rules as embodied in National Fire Protection Association (NFPA) Standard 805 [2] and the Code of Federal Regulations (CFR) Section 10CFR50.48(c) [3].

In contrast, fire PRAs for Low Power and Shutdown (LPSD) conditions have been conducted in only a few cases and all of the known analyses were based on methods and data that pre-date the RES/EPRI full-power fire PRA method. Methods for conducting such studies have not previously seen the same level of development as have the full-power methods and no comprehensive source for analysis guidance compatible with the current state-of-the art fire risk methods (e.g., [1]) is known to exist prior to this document. The methodology presented here is presented as an extension of, or supplement to, the RES/EPRI full-power fire PRA method [1]. That is, the LPSD method relies extensively on the extension of full-power analysis methods to LPSD conditions. As a result, documentation of the methodology as presented here focuses on those elements where the full-power methods should be adapted or extended to address LPSD conditions.

1.2 Scope

LPSD plant operating states (POSs) potentially include a broad range of conditions for power, temperature and pressure levels. For reference, the *American National Standard Low Power and Shutdown PRA Methodology*[1] [4] defines key terms relevant to LPSD PRAs as follows:

1) "Low Power - Power levels at which major secondary components are out of service as a plant shuts down or starts up. This is typically a transition mode to/from hot/cold

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[1] The cited quotes are based on the joint American National Standards Institute (ANSI) and American Nuclear Society (ANS) standard ANSI/ANS-58.22-200x, DRAFT #8C, for the Risk Informed Standards Committee (RISC) Reballot & Public Review, June 2008. At the time the current document was prepared, this was the most recent version of the LPSD PRA standard available. The reader should be aware that the standard is a document in transition and should review updated versions, as available, for wording changes.

shutdown. Designated as Startup in a boiling water reactor (BWR) when transitioning from cold shutdown to power operations."

2) "Low power: a POS (or set of POSs) during which the reactor is at reduced power, below full-power conditions. In this POS, the power level may be changed as the reactor is shutting down or starting up. The power level that distinguishes full power and low power is the power level below which major plant evolutions are required to reduce or increase power (e.g., taking manual control of feedwater level)."
3) "LPSD evolution: a series of connected or related activities, such as a reduction in power to a low level, or plant shutdown, followed by the return to full-power plant conditions. LPSD evolutions are modeled as a series of POSs. Outage types are a general type of a shutdown evolution, and a refueling outage is a specific example. Reducing power to 30% in order to conduct maintenance or an operational activity is another example of a low-power evolution. LPSD evolutions are characterized by a transition down to the POS where the activity is conducted, followed by a transition back to full power."

Note that even though these definitions all come from the same document, they are not entirely consistent. It is anticipated that the final revisions of the draft LPSD PRA standard will resolve the differences and settle on final definitions for these terms. Generally, the differences in phrasing are relatively minor and this methodology adopts these definitions with the intent of maintaining consistency with this quality standard. Consistent with these excerpts and for general purposes, this methodology assumes that LPSD PRA might include plant operations at roughly the 30% power level and lower.

One implication of this assumption is that LPSD conditions encompass a very broad spectrum of potential operating conditions. At one end of the POS spectrum, the reactor may be producing power with the control rods partly out, pressure and temperature of the main cooling loop very close to full-power conditions, and decay heat cooling systems not yet functioning (due to system pressures). At the other end of the POS spectrum, LPSD includes refueling outage conditions where all the rods are inserted, the main reactor vessel is open and flooded with refueling pool borated water, and the reactor is at near-ambient temperature. During refueling, depending on the maintenance needs, only one decay heat removal loop may be available for a limited time and plant modification activities could be underway.

1.3 Document Organization

An overview of the LPSD fire PRA method is provided in Section 2 below. The overview defines the tasks of the methodology. The selection of POSs and the equations for estimating overall plant core damage frequency (CDF) and large early release frequency (LERF) are discussed in Section 3. Section 4 provides a detailed discussion of each technical element of the analysis methodology. Note that the subsections within Section 4 follow the same ordering as the chapters and technical tasks as defined in Volume 2 of the RES/EPRI full-power fire PRA methodology [1].

2 Overview of LPSD Fire PRA Methodology

2.1 Structural Overview

An internal fire event during LPSD operations can occur from either an equipment item malfunction (e.g., a short in a switchgear may lead to arcing inside the device, rapid release of energy, and ignition of switchgear internals) or a transient combustible or activity (e.g., welding done for repair or plant upgrade). These are the same two types of fire events considered in full-power fire PRA. It is possible that the characteristics of an LPSD fire event (e.g., intensity or amount of fuel available) may be different from a similar class of events during full-power operation. However, the underlying fire behaviors of interest remain the same (e.g., ignition of combustible materials leading to plume formation, radiant heating, and other potentially damaging effects). Therefore, in principle, the methodology developed for full-power fire PRA [1] should be applicable to LPSD conditions. Clearly some of the parameters and conditions should be adjusted to reflect the special conditions of LPSD POSs.

The methodology presented in this document is structured to coincide with the RES/EPRI full-power fire PRA method. Therefore, the discussions provided in this document assume that the reader is familiar with that method and the related data as presented in reference [1]. The task elements of the RES/EPRI full-power fire PRA method are each discussed. These discussions focus on the differences introduced by virtue of the LPSD perspective. Note that for some task elements the differences are quite minor or even nonexistent.

The RES/EPRI full-power fire PRA methodology defines 16 technical task elements and provides a detailed discussion, supporting data, and other information for each task. Figure 1 (presented at the end of Section 2) is the flow chart used in the RES/EPRI full-power fire PRA method to illustrate the interrelationship among the different tasks of the methodology. The same set of tasks and flow chart apply to LPSD fire PRA. Each task is discussed separately below in Section 3.

The RES/EPRI full-power fire PRA method for at-power conditions assumes that certain information will be available based on prior completion of a corresponding plant internal events PRA. If an internal events analysis is not available, then the fire PRA analyst is responsible for developing and validating the required information. Similarly, the LPSD fire PRA method assumes that certain information will be available based on prior completion of a LPSD internal events PRA. The information that is assumed to be available includes:

- Definition of LPSD POSs that will be addressed in terms of core power level, core cooling system pressure and temperature, equipment status (functional or under maintenance), special activities (e.g., maintenance and plant upgrade), status of barriers (e.g., doors propped open to allow certain activity, etc.);
- A list of initiating events for each POS as defined in the LPSD internal events PRA (e.g., loss of service water, loss of direct current (dc) power, etc.);
- A plant response model for each LPSD initiating event and for each relevant POS of interest;

- A list of equipment and their failure modes of interest to the LPSD internal events PRA; and
- Human error scenarios integrated in the LPSD internal events plant response model.

It is also assumed that an at-power fire PRA has been completed and is available. Information assumed to be available based on the at-power fire PRA includes:

- Plant partitioning results which divide the plant into fire compartments or, equivalently, into physical analysis units (PAUs);[2]
- The listing of equipment included in the at-power fire PRA plant response model (i.e., selected equipment per Task 2 of the RES/EPRI full-power fire PRA method);
- The listing of cables associated with selected equipment;
- Any additional initiating events that are specific to the fire analysis;
- Equipment and ignition source counting results;
- Control circuit failure modes and effects analysis reports; and
- Component and cable mapping/routing results for the circuits in the circuit analysis report.

If any of this information is not available, the analyst should generate the needed information.

2.2 Key Assumptions and Potential Limitations

This methodology is based on a number of key assumptions, and these key assumptions which have implications for both the scope of the methodology and for potential limitations to application of the methodology. These key assumptions and the associated implications are summarized as follows.

- Assumption 1: The LPSD method assumes that a full-power fire PRA has been completed consistent with the general approach defined by the RES/EPRI full-power fire PRA methodology.
  - Impact of this assumption on the methodology: The LPSD method takes as given that certain analysis tasks have already been completed and will, at most, require review and updating to address the LPSD conditions. For example, it is assumed that the task of identifying and counting fixed fire ignition sources within the plant has been completed. Hence, the LPSD analysis should only consider changes that might be associated with LPSD conditions (e.g., changes in the operational status of equipment, changes in the nature and likelihood of transient fuel sources that might be introduced during an outage, etc.).

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[2] NUREG/CR-6850, EPRI 1011989 [1] uses the phrase “fire compartments” and the American Society of Mechanical Engineers (ASME) PRA quality standard [10] uses the phrase “physical analysis units.” The differences are largely semantic in nature and this method document has adopted the language of the PRA standard in this regard.

  - Implications: This assumption is thought to carry few practical implications. An early conclusion reached by the authors was that it is wholly impractical to perform an analysis of LPSD fire risk without first completing an assessment of the full-power fire risk. An analyst attempting to conduct an LPSD fire analysis without first completing a full-power fire analysis would, in effect, be forced to do nearly all of the work associated with a full-power fire risk study simply to establish the required input for beginning the LPSD risk study.

- Assumption 2: The LPSD fire PRA method assumes that an LPSD PRA has already been completed for internal event accident initiators.

  - Impact of this assumption on the methodology: This parallels an equivalent assumption made in the RES/EPRI full-power fire PRA methodology; namely, that a full-power internal events PRA has been completed prior to conducting the full-power fire PRA. In general, the impact on the LPSD fire PRA methodology is also the same; namely, the LPSD fire PRA method calls for the analyst to build a fire plant response model beginning from the corresponding model developed for the LPSD internal events PRA. The fire method thereby focuses on incorporating required changes and additions to address those aspects of plant response that are unique to fire (e.g., fire-induced spurious actuation of plant equipment, potential new initiators or sequences, and fire response procedures).

  - Implications: The most significant implication of this assumption is that the LPSD fire PRA method assumes that the relevant POSs to be evaluated will have been defined in the LPSD internal events PRA. This method assumes that, at least nominally, the same set of POSs is then carried forward to the fire PRA. Based on this assumption, this document does not explicitly address the process or criteria by which the POSs will actually be defined. Defining LPSD POSs is an analytical challenge with far-reaching implications and is the focus of substantial debate in the more general PRA community. The resolution of this challenge lies beyond the scope of this document. It is also acknowledged that the fire analysis will present unique challenges with respect to POS definition. This method, for example, recommends that the LPSD fire PRA characterize and quantify the fire-specific plant configuration changes that occur with respect to each POS analyzed (e.g., breaching of fire barriers, staffing by plant personnel and contractors, introduction of new transient combustibles, increased hot work, fire protection system unavailability, maintenance activities, etc.). The implied work scope could become burdensome if a high level of detail for all possible POSs is sought. Methods for the management of the work scope challenge will likely develop through practical application, but cannot be defined a-priori. One general approach that might be especially helpful would be screening methods that would define the subset of POSs to be included in, or conversely excluded from, the quantitative fire analysis; but again, the more general state of POS definition guidance is not yet mature enough to support development of such screening approaches.

- Assumption 3: Development of detailed human reliability analysis (HRA) quantification methods for application to the LPSD fire PRA lie beyond the scope of this document.

  - Impact of this assumption on the methodology: This parallels an equivalent assumption made in the RES/EPRI full-power fire PRA methodology; namely, that post-fire HRA methods will rely upon general practice for HRA in other contexts and that specific guidance for application to fire conditions will be developed by the HRA community. This document does not explicitly address HRA quantification methods.
  - Implications: HRA is a unique area of methodology development whose implications extend well beyond the boundaries of a fire PRA. HRA quantification in the context of general LPSD plant operations is an active area of debate and development in the HRA technical community. A joint effort is already well underway between RES and EPRI to develop fire HRA quantification guidance for full-power fire PRA applications (see further discussion in Section 4.12). The LPSD fire PRA method assumes that the HRA community will ultimately develop LPSD analysis guidance and will extend that guidance to include the treatment of fire conditions. Section 4.12 discusses prior LPSD HRA analyses and applications, the updated EPRI-RES fire HRA guidance and considerations relevant to the application of that guidance to LPSD applications. However, the resolution of the LPSD HRA challenge lies beyond the scope of this document.

- Assumption 4: LPSD Fire frequencies are estimated based on past plant experience in the same manner that fire frequencies were estimated for the RES/EPRI full-power fire PRA methodology and using the same root database (i.e., the EPRI fire event database (FEDB)).
  - Impact of this assumption on the methodology: The development of a new FEDB or the gathering of substantially new information for incorporation into the existing FEDB lie beyond the scope of this project. Hence, this method followed the approach used in the RES/EPRI full-power fire PRA methodology. If the RES/EPRI full-power fire PRA methodology concluded that the frequency of fires for a given fire source was not dependent on the POS, this method has made the same assumption (i.e., the fire frequency for many ignition source bins reflects fires occurring during all modes of plant operation). New fire frequencies are calculated only for those ignition source bins where the RES/EPRI full-power fire PRA methodology concluded that the shutdown fire frequency might vary substantially from the at-power fire frequency (e.g., transients and hot work fires).
  - Implications: The existing FEDB has limitations that make it difficult to parse fire events to the extent that might be considered desirable. While this was also true for the RES/EPRI full-power fire PRA methodology, there are some unique implications in the context of LPSD conditions. In particular, while there are some exceptions, the fire event database does not generally identify the specific POS that a plant was in when a particular fire occurred. Rather, the vast majority of records only classify the POS as either at-power or shutdown (or they fail to specify a plant state at all). As a result, it is not currently possible to provide estimates of fire frequency that are POS-specific. An RES/EPRI collaborative effort is underway to expand and improve the EPRI FEDB. The planned improvements should afford some opportunity to improve the ability to parse fire events.

- Assumption 5: Consistent with the LPSD PRA standard [4][3], the LPSD fire PRA end states considered here are limited to CDF and LERF.
  - Impact of this assumption on the Methodology: While the methodology presented here could be extended to include other end states, it should be emphasized that this document makes no attempt to address any end states other than CDF and LERF.
  - Implications: During certain LPSD POSs, depending on the specific conditions, radionuclide release may occur from events other than core damage (the focus of full-power PRA). For example, during a refueling outage coolant boiling in the core, uncovering the core, or fuel bundle mishandling could be considered as possible end-states for a risk analysis. Consistent with the standard [4], these alternative end states lie outside the scope of this methodology. Also consistent with the standard [4], this document excludes consideration of potential release scenarios associated with either the spent fuel pool or on-site dry cask storage of spent fuel.

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[3] At the time the current document was prepared, reference [4] was the most recent version of the LPSD PRA standard available. The reader should be aware that the standard is a document in transition and should review updated versions, as available, for wording or scope changes.

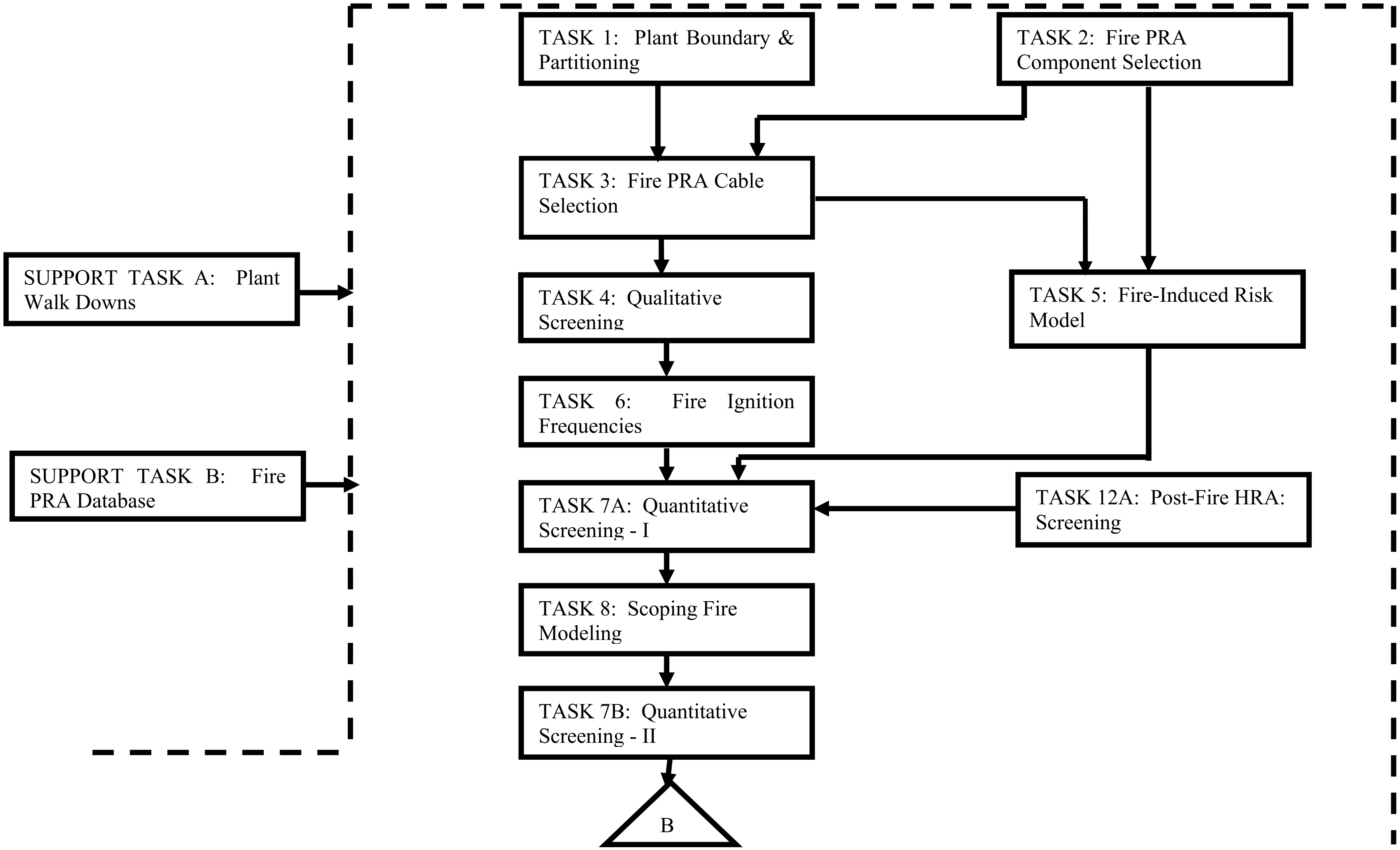

Figure 1: Fire PRA Process and Module Structure (part 1 of 2).

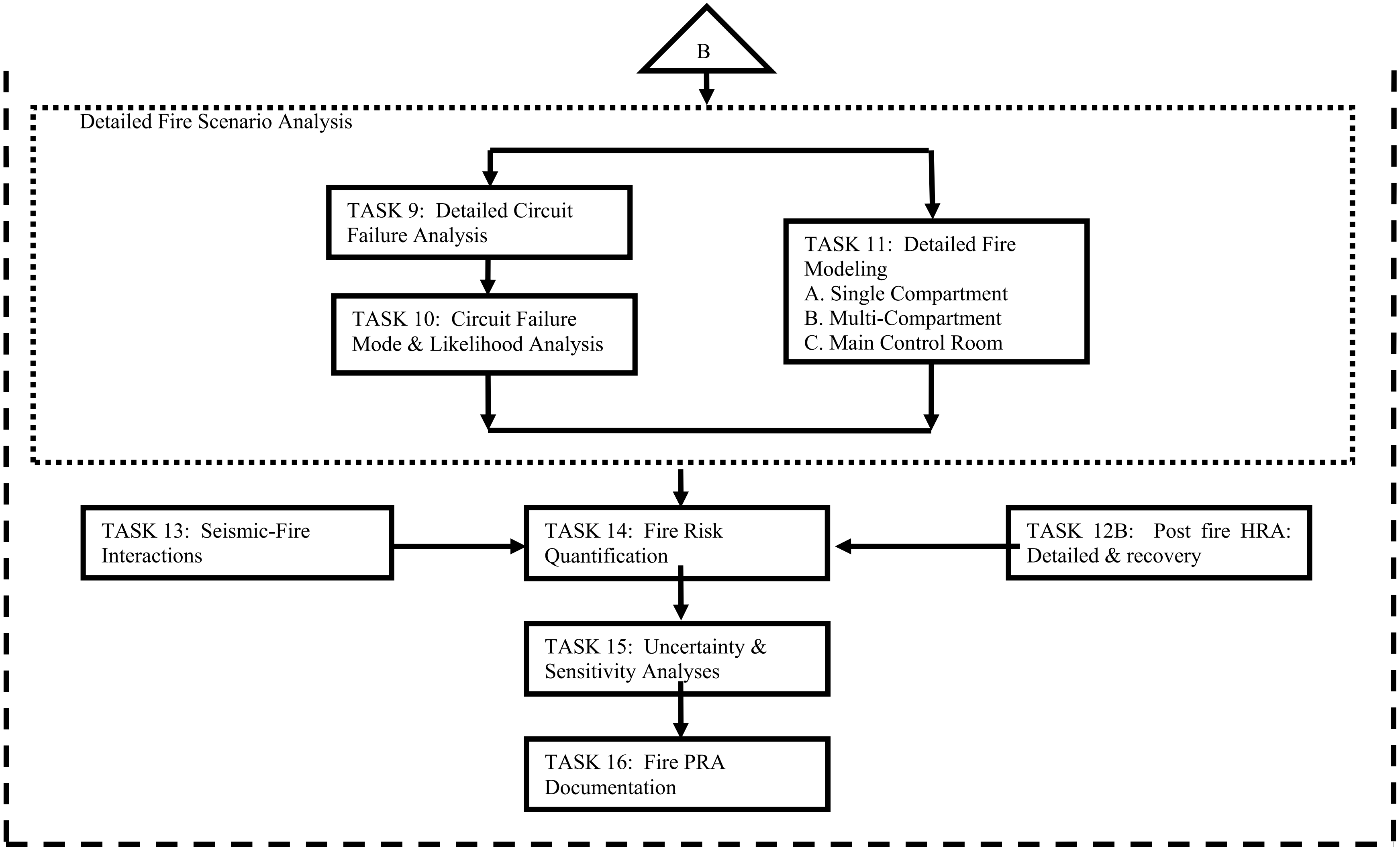

Figure 1: Fire PRA Process and Module Structure (part 2 of 2).

3 LPSD PRA CDF and LERF

A key challenge of LPSD PRA, both for internal events and fire, is the definition of the POSs to be analyzed. There are many possible solutions to this challenge. This document takes no position as to the ‘correct’ solution. Whatever approach is ultimately taken, this method assumes that a POS set will be defined as a part of the plant’s internal events LPSD PRA and that the defined POS set will be equally valid and inclusive so as to serve the needs of the LPSD fire PRA. It is therefore assumed that the analyst will have a set of POSs defined prior to attempting LPSD fire PRA effort. Two general approaches to defining the POSs are anticipated. The POS set could be “complete” so as to cover all possible POSs in substantive detail. The set could also be a limited, well defined grouping of POSs intended to represent a typical outage or for use in a focused-scope analysis. This method is neutral to this aspect of the analysis. The approach taken to defining POSs for analysis will clearly impact the scope of the analysis, but will not alter the fundamental nature of the fire PRA methodology. Instead, the choice of approach will be driven by the objectives and intended applications of the analysis.

An evaluation based on a more complete set of POSs will facilitate modeling of actual plant configurations and equipment status changes that could increase, or reduce, fire risk. For each POS that exists there may be special plant configurations that are unique to a specific outage (e.g., steam generator replacement, flooding of the spent fuel pool). These special plant configurations will require particular consideration since initiators and mitigating equipment may vary from the original POS. PRA models for each POS should also reflect each special configuration.

If the objective of the analysis is to estimate the total risk over the course of an outage sequence (e.g., from the beginning of plant shutdown from power to the point of restart), the CDF and LERF calculations should be repeated for each POS and combined according to the following equation:

$$\mathrm{CDF\Sigma POS} = \Sigma_i\ \mathrm{CDFPOS(i)} \times \mathrm{ft}_{\mathrm{POS(i)}}$$

Where:

$\mathrm{CDF\Sigma POS}$: The total CDF of all POSs combined in number of events per reactor year

$\mathrm{CDFPOS(i)}$: The instantaneous CDF of specific POS(i)

$\mathrm{ft}_{\mathrm{POS(i)}}$: The fraction of time that each POS exists

If a specific one-time POS under a specific set of conditions is analyzed, the CDF and LERF should be estimated using the same equation, except that only one POS is considered. Therefore, we can write:

$$\mathrm{CDF}_{\mathrm{POS(i)}} = \mathrm{CDFPOS(i)} \times \mathrm{ft}_{\mathrm{POS(i)}}$$

Where:

$CDF_{POS(i)}$: The CDF of POS(i) in number of events per reactor year

CDFPOS(i): The instantaneous CDF of specific POS(i)

$ft_{POS(i)}$: The fraction of time that POS *i* exists

The same set of equations applies to LERF calculations where CDF is simply replaced with LERF.

4 Detailed Methodology

4.1 Task 1: Plant Boundary Definition and Partitioning

The purpose and scope for this task remains the same as presented in reference [1]. This section provides supplemental guidance for conducting the plant boundary definition and partitioning tasks in support of the LPSD fire PRA. As in the full-power fire PRA, the plant is divided into a number of PAUs. The analysis then considers the impact of fires in a given PAU, and fires that might impact multiple PAUs. This practice supports both the organization of the PRA information and analysis, and provides a framework for reporting risk results.

Task 1 establishes the process for defining the overall plant boundary and partitioning of the plant into PAUs. The product of this task will be a list of PAUs that encompasses the nuclear power plant under analysis.

Analysts have two choices: (1) use the same set of PAUs as per the definitions established in the full-power fire PRA or (2) redefine the PAUs based on the barrier configurations and conditions specific to the POS. Both approaches have merits but this report advocates for maintaining the PAU definitions as per the full-power fire PRA with few exceptions. This approach ensures that plant locations are identified consistently among the analyses and will allow the results for the same plant location under different operating conditions to be quickly and easily identified. If the PAU boundaries are redefined, then tracking results becomes far more difficult and burdensome. The two significant exceptions to this recommendation are as follows:

(1) The analysis should verify that the full-power fire PRA plant boundary encompasses all plant areas of potential interest to the LPSD fire PRA. If it does not, then the global analysis boundary is expanded and new PAUs are defined.

(2) The analysis should consider the treatment afforded the containment structure in the full-power fire PRA and determine if an alternative treatment is appropriate. Containment fires are relatively rare while the plant is at full-power operation. For those BWRs with inerted containment, fires during full-power operation are not analyzed (no fire frequency is assigned to these containments per the guidance in reference [1]). During LPSD operations, these conditions can change and the changes could impact containment partitioning decisions.

The primary challenge to the LPSD fire PRA with respect to Task 1 is that the partitioning elements that defined the compartments in the full-power fire PRA (e.g., walls, ceilings/floors, spatial separation, etc) are subject to modification during LPSD plant operations. For example, equipment hatches in ceilings/floors may be removed, normally closed doors may be propped opened, fire barrier penetrations may be breached (e.g., to support equipment or cable work), the containment structure may be open, and for BWRs, containment will no longer be inerted. The LPSD fire PRA will need to define and address such changes, but this need not force changes to previous (i.e., at power) partitioning decisions. Rather, changes in the status or integrity of a credited partitioning feature or element can be addressed during Task 11, and in particular Task 11c - the multi-compartment fire analysis (see Section 3.11 for additional discussion).

If the decision is made to alter the partitioning of any plant locations, the analysis should (1) define the partitioning changes and (2) provide a concise mapping between PAUs as defined in the full-power fire PRA and in the LPSD fire PRA. As in the full-power fire PRA, the LPSD PAUs should collectively encompass all locations within the global analysis boundary with no exclusions and no overlap between compartments (the set of PAUs is both complete and exclusive).

In Section 1.3.1 of reference [1]; the guidance cautions the analyst to avoid "excessive partitioning" and an over-reliance on multi-compartment fire scenarios as significant contributors to plant fire risk. If the recommendations discussed above are followed (i.e., the same PAU definitions are retained from the full-power analysis), then it is likely that there will be more contributing multi-compartment scenarios for LPSD than the full-power fire PRA. This is because normally closed fire barriers and other partitioning features may be opened during LPSD operations. This is inevitable, and is not considered to detract from the quality or validity of the LPSD fire PRA provided appropriate treatment is afforded to the relevant multi-compartment fire scenarios (i.e., in Task 11c).

The same procedure as that described in reference [1] for full-power fire PRA applies here as well with the following clarifications.

- Step 1: Selection of Global Plant Analysis Boundary:

  This task begins with an assessment of the global plant analysis boundary definition established in the full-power fire PRA. The guidance provided in reference [1] seeks a liberal definition of the global plant analysis boundary. Hence, for most analyses it is considered unlikely that the boundary will need to be expanded to suit the LPSD fire PRA; however, the LPSD analysis should determine whether the global plant analysis boundary should be expanded to encompass new areas of the plant. The definition of the global plant analysis boundary may need to be expanded if any locations excluded from the full-power analysis are identified as potentially relevant to the LPSD analysis. For example, the unit under analysis may establish electrical ties via temporary cabling to a sister unit during shutdown that would not be present while at power (e.g., to make up for de-energized power supply busses undergoing maintenance during the shutdown). If these ties meet the criteria for equipment/cable selection and the corresponding areas of the sister unit were outside the global analysis boundary for the unit's at-power fire PRA, then the LPSD fire PRA global analysis boundary should expand accordingly.

  As with the full-power fire PRA, the LPSD fire PRA global plant analysis boundary should encompass all areas of the plant associated with both normal and emergency reactor operating and support systems, and power production (e.g., the turbine building). The unique aspect of this assessment for the LPSD analysis is that the terms "normal and emergency reactor operating and support systems" should encompass all defined POSs to be considered in the analysis rather than just full-power conditions. This holds the potential to introduce plant locations that were deemed outside the scope of the full-power fire PRA.

  Selection of the LPSD fire PRA global plant analysis boundary should begin with the full-power fire PRA global plant analysis boundary. A review should be performed to ensure that locations not included within the full-power boundary could not contribute to fire risk under any of the defined LPSD POSs. In particular, the LPSD fire PRA plant analysis boundary should encompass all locations, including qualifying locations associated with a sister unit at a multi-unit site, that house any of the LPSD fire PRA components and cables identified in Tasks 2 and 3 (see next two sections).

- Step 2: Plant Partitioning:

The discussions provided in Section 1.5.2 of reference [1] apply in full to the LPSD fire PRA. As a general practice, this method recommends that the PAUs (i.e., the plant partitioning results) as developed for the full-power fire PRA be applied without modification to the LPSD fire PRA with two specific exceptions:

(1) For any new locations added to the global analysis boundary in Step 1, partition those locations into PAUs consistent with the guidance in Section 1.5.2 of reference [1].

(2) It is recommended that a review of the containment structure be performed to assess whether or not additional partitioning is appropriate.

With respect to item (2) above, in a typical full-power fire PRA the containment structure is either not analyzed in detail (i.e., in the case of those plants whose containments are inerted during plant operations) or analyzed in limited detail (e.g., due to the relatively low frequency of fires inside containment during power operations that can affect core cooling). These conditions (inerting and low fire frequency) may not apply to LPSD operations and the analyst should anticipate that a more thorough examination of containment fires will be required. Hence, the purpose of item (2) above is to ensure that due consideration is given to the potential analytical needs of the containment fire analysis during the plant partitioning task. As always, partitioning decisions are ultimately up to the analyst but additional partitioning of the containment structure should be considered.

- Step 3: Compartment Information Gathering and Characterization:

The discussions provided in Section 1.5.3 of reference [1] apply in full to the LPSD fire PRA.

- Step 4: Documentation:

The discussions provided in Section 1.5.4 of reference [1] apply in full to the LPSD fire PRA. In addition, the analyst should take particular care to document any changes in plant partitioning made to support the LPSD fire PRA as compared to the full-power fire PRA. If any partitioning changes are made, task documentation should define those changes and provide a mapping of LPSD PAUs to full-power fire compartments.

4.2 Task 2: Fire PRA Component Selection

4.2.1 Background

The objective of Task 2 is to create the LPSD fire PRA component list[4]. This list identifies the plant components that will be modeled in the LPSD fire PRA. The component list also identifies

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[4] As in the full-power procedure, the terms "equipment" and "component" as used here are considered synonymous and are meant to include plant components such as valves, fans, pumps, etc.; structures; barriers; indicators; alarms; and other devices as appropriate. The terms generally exclude electrical cables as these are dealt with explicitly (see Task 3).

plant equipment for which the corresponding cables (power, control and instrumentation – see Task 3) need to be identified and located.

This task builds upon foundations of equipment selection established by the full-power fire PRA. It also builds upon foundations established in a corresponding internal event LPSD PRA. Hence, as noted in Section 2, these two analyses are considered critical inputs to this task. If either analysis is not available, the analyst faces a substantial additional burden to generate the information that would normally be imported from these analyses and that effort lies outside the scope of this document.

Given the wide range of possible POS conditions, essentially all of the components selected for inclusion in the full-power fire PRA will also be relevant to the LPSD fire PRA and should be retained in the LPSD fire PRA component list. However, component selection will need to be augmented with additional components unique to the conditions posed by the specific POSs associated with shutdown and with equipment outages during LPSD conditions (e.g., loss of the redundant train of a system to a fire while the other train is out of service for maintenance).

The process for generating the LPSD fire PRA component list is fundamentally the same as the full-power analysis. The analyst, however, should consider each POS separately to ensure that potential accident initiators and mitigating equipment relevant to each POS are properly accounted for.

Overall and for each POS, the component list needs to span:

(1) equipment that, if affected by a fire, will cause an initiating event such that the appropriate fire-induced initiators can be defined;

(2) all equipment necessary to support those mitigating functions and operator actions that are credited in the analysis in response to any initiator; and

(3) equipment that can be a source of undesirable responses adverse to safety during a fire-induced accident sequence, (e.g., fire-induced spurious operations).

The considerations cited for the selection of equipment in Section 2.2 of reference [1] are fully applicable to the LPSD fire PRA. In addition, it is recommended that the LPSD fire component list include the following:

(1) all components included in the full-power fire PRA, and

(2) all components credited in the Internal Events LPSD PRA, and in particular, equipment associated with electrically diverse systems.

The input to Task 2 is much the same as those identified in Section 2.4.1 of reference [1] with the following additions:

(1) Task 2 includes the mapping of identified components to plant locations (e.g., fire areas and/or PAUs). It is strongly recommended that the LPSD fire PRA use the same plant boundary and compartment definitions and location identification nomenclature as established in the corresponding full-power fire PRA. If the global analysis boundary is expanded to accommodate the needs of the LPSD fire PRA, then the additions should be clearly documented (e.g., identify locations that were deemed outside the scope of the full-power fire PRA but are included in the LPSD fire PRA). This approach will greatly simplify the process of component tracing and location documentation.

(2) The internal events LPSD PRA model for the specific POSs under consideration and the corresponding equipment lists are a required input.

(3) Plant procedures applicable to the POSs being considered (e.g., emergency operating procedures, fire procedures, annunciator response procedures) are required in addition to at-power operating procedures.

(4) The analysis will need to review plant Technical Specifications to determine possible limiting conditions of operation (LCOs) applicable to each defined POS conditions (see Task 2 Step 3).

4.2.2 Procedure

The steps that follow provide a method to create the LPSD fire PRA component list. The step structure is identical to that provided in Section 2.5 of reference [1]. As with the full-power fire PRA, as a practical matter, the LPSD fire PRA component selection task is an iterative process. Hence, as other tasks are performed, there may be reason to revisit and redo portions of Task 2 during the development, screening, and eventual quantification of the LPSD fire PRA.

- Step 1: Identify Internal Events LPSD PRA Sequences to be included (and those to be excluded) in the LPSD fire PRA Model.

This step for the fire LPSD task is identical to the corresponding step as described in Section 2.5.1 of reference [1] with one modification. For the purposes of the LPSD fire PRA, Step 1 reviews accident sequences from the *full-power fire PRA and the internal events LPSD PRA* (rather than only the internal events *full-power* PRA.)

Possible Elimination of Sequences and Equipment - The identification of sequences that could generally be eliminated from the LPSD fire PRA is similar to the corresponding analysis element in reference [1] with the following additions:

(1) In determining which sequences and equipment to include, or potentially exclude, from the LPSD fire PRA, consider all sequences included in the full-power fire PRA and those included in the internal events LPSD PRA.

(2) It is recommended that all components included in the full-power fire PRA be retained for (i.e., not eliminated from) the LPSD fire PRA with few exceptions. In essence, the full-power fire PRA will already have established component locations and will have identified and traced related cables. Hence, there is likely little benefit to be gained by excluding such components from the fire LPSD analysis especially given that the LPSD fire PRA will include low-power (e.g., startup) POSs that will be quite similar in nature to the full-power plant configuration. If any components that were included in the full-power fire PRA are excluded from the LPSD fire PRA, the exclusion should be noted and explained, including a discussion of the potential impact of these exclusions on the risk results.

(3) As in the full-power fire PRA, justification for the exclusion of any sequences or equipment and the resulting impact on the "reduced" PRA model should be noted. In particular, the analyst should take care not to eliminate sequences or equipment that could adversely affect equipment credited in the LPSD fire PRA. For example, elements of an electric power distribution system may be considered for elimination (e.g., dc power distribution system elements). However, the analyst should be careful

not to eliminate those parts of the system that may be needed for proper functioning of credited equipment items (e.g., instrumentation loops).

Possible Additions of Sequences and Equipment - Considerations relative to the addition of sequences and equipment are essentially the same as for the corresponding analysis element in the full-power fire PRA with the following clarifications:

(1) As was the case for the full-power fire PRA as compared to the full-power internal events PRA, some sequences that were screened out of the internal events LPSD PRA based on low frequency of occurrence may need to be retained in the LPSD fire PRA. The bases for such additions would be similar to those leading to additions to the full-power fire PRA. Specifically, a search should be conducted, in concert with carrying out all the steps of this procedure, for new functional challenges in the plant not otherwise accounted for especially because of fire-induced spurious actuation considerations.

- For example, spurious actuation of a high pressure pump while the reactor vessel is closed but in cold shutdown may lead to pressurizer safety relief valve (SRV) lift. Spurious actuation of the pump may have been deemed of sufficiently low probability in the internal events LPSD PRA that the sequence may have been screened out. However, fire-induced spurious actuation of the same pump (e.g., due to control cable failures) might be likely enough to warrant retention of the sequence.

A review should be conducted for such scenarios originally eliminated from the internal events LPSD PRA to determine if new components should be added to the LPSD fire PRA component list implying that those components, their failure modes, and the associated sequences would be included in the LPSD fire PRA plant risk model (see Task 5). Particularly when considering the possible effects of spurious operations, new accident sequences and associated components of interest beyond those considered in the Internal Events LPSD PRA may be identified that should be addressed in the LPSD fire PRA. Each POS should be considered individually to determine applicability. Typically, new sequences might arise as a result of spurious events that:

- cause a loss of coolant accident (LOCA), e.g., drain down events;
- adversely affect plant pressure control, e.g., letdown or safety relief valve events;
- cause loss of cooling to core; or
- introduce other “new” scenarios that may not be addressed in the internal events LPSD PRA.

(2) As with the full-power fire PRA, a review of the fire emergency procedures (FEPs) or similar fire-related instructions as such instructions apply to various LPSD POSs should be conducted (see also Task 12). In particular, fire-specific manual actions designed to preclude or overcome spurious operations will likely not have been addressed in the Internal Events LPSD PRA. For example:

- An FEP may require shutdown of a pump from the switchgear to avoid spurious actuation of the pump and pump damage due to cavitation. This may cause demands on the pressurizer SRV and lead to sequences not modeled in the Internal Events LPSD PRA.

- Fire specific manual actions may cause an unintentional failure of a safety function or a subset of that functional response. For example, a proceduralized action may be to trip a power supply thereby disabling ("failing") certain equipment in the plant.

- As with full-power considerations, the likely timing of the operator action as compared to when the affected component is needed should also be considered.

- Step 2: Review the Internal Events LPSD PRA Model Against the Fire Safe Shutdown Analysis:

The impact of Step 2 on the LPSD fire PRA is likely to be more limited than the impact of this step on the full-power fire PRA. However, this step does retain some relevance to the LPSD fire PRA and should not be neglected.

The fire safe shutdown analysis addresses regulatory requirements to demonstrate that, in the event of a plant fire, the plant will retain the ability to achieve hot-shutdown (or hot-standby) and ultimately to achieve and maintain cold shutdown. Hence, the safe shutdown procedures will overlap some of the POSs that will likely be defined in the LPSD fire PRA. To the extent that this overlap exists, Step 2 should be completed.

The underlying steps (i.e., steps 2.1 through 2.5) are executed largely consistent with the treatment afforded in the full-power fire PRA. The most significant difference is that the review compares the fire safe shutdown analysis to the plant risk model developed for the internal events *LPSD* PRA rather than the treatment provided in the internal events *full-power* PRA. The reconciliation effort in steps 2.1 through 2.4 compares the fire safe shutdown analysis to the internal events *LPSD* PRA rather than to the internal events *full-power* PRA. When reconciling system or equipment differences due to end-state and mission considerations, the fire safe shutdown analysis will likely not deal at all with various POSs associated with the LPSD fire PRA. In particular, the fire safe shutdown analysis will typically not address any aspects of plant operations during refueling stages of a plant shutdown. When considering specific review of manual actions, the reconciliation effort should compare the fire safe shutdown analysis to the internal events LPSD PRA rather than to the internal events full-power PRA. Also, with respect to manual actions to be credited in the LPSD fire PRA, considerations should include both the need to achieve and maintain safe shutdown (e.g., given an automatic or manual trip from a low-power POS) and the need to maintain safe and stable conditions during other non-power POSs (e.g., refueling evolutions).

- Step 3: Identify Fire-Induced Initiating Events Based on Equipment Affected:

The role of this step in the analysis is essentially identical for the LPSD fire PRA as for the full-power fire PRA. That is, to the extent the above steps have not already done so, this step addresses that equipment which, if affected by a fire, could cause an initiating event (e.g., forced shutdown of the plant from a low power state or a drain down event for other shutdown evolutions). As in the full-power analysis, the goal of Step 3 is to identify what initiator(s) will likely occur if a fire in any given compartment affects equipment identified on the LPSD fire PRA component list. For guidance, see Section 2.5.3 of reference [1] with the following clarification: In addition to the considerations applicable to the full-power fire PRA, for the LPSD fire PRA, consideration also extends to equipment whose failure would compromise the ability to maintain a safe and stable condition for each POS being considered. It is anticipated that new initiating events may need to be identified stemming from the specific conditions imposed by the POS. It must be noted here again that this guidance is focused on CDF and LERF. Other radionuclide release possibilities are not considered as part of the scope of this document.

- Step 4: Identify Equipment with Potential Spurious Actuations that may Challenge the Ability to Safely Maintain the Plant During Each POS:

The role of this step in the analysis is essentially identical for the LPSD fire PRA as for the full-power fire PRA. This step is aimed at further expanding the LPSD fire PRA component list, and thus potentially the LPSD fire PRA plant risk model (Task 5), to include adequate consideration of the potential for harmful fire-induced spurious actuations. For guidance, see Section 2.5.4 of reference [1] with the following clarifications:

(1) In addition to the considerations applicable in the full-power fire PRA, for the LPSD fire PRA it also extends to equipment whose spurious actuation would compromise the ability to maintain a safe and stable condition for each POS being considered.

(2) The systematic review of potential spurious actuation concerns is conducted on the basis of accident sequence types and related mitigation system functions included in the internal events LPSD PRA plant risk model rather than the internal events full-power PRA plant risk model.

(3) Table 2-2 of reference [1] presents (illustrative only) examples of how single and multiple spurious actuation failures might be important for some accident sequences. In addition to those examples provided for full-power conditions, the LPSD PRA should include consideration of spurious actuations impacting secondary-side cooling functions because these either may not have been considered, or may have been considered and screened out, during the full-power fire PRA.

- Step 5: Identify Additional Mitigating, Instrumentation, and Diagnostic Equipment Important to Human Response:

The goal of this step in the LPSD fire PRA is identical to that of the corresponding step in the full-power fire PRA [1]. Namely, the goal is to expand the LPSD fire PRA component list, and thus potentially the LPSD fire PRA plant risk model (Task 5) to include other mitigating equipment, instrumentation, and diagnostic equipment necessary for human actions if not already addressed in previous steps for each POS. The structure and role of the underlying steps (5.1 and 5.2) remains unchanged.

  - Step 5.1: Identify Human Actions of Interest: See Section 2.5.5.1 of reference [1] for guidance with the following clarifications:

  (1) The identification of human actions gives consideration to those human actions credited in the internal events *LPSD* PRA rather than those actions credited in the internal events *full-power* PRA.

(2) The review of human actions should consider all relevant plant procedures for all POSs being considered. This should include both general plant operations and any fire-specific procedures as available.

- Step 5.2: Identify Instrumentation and Diagnostic Equipment Associated with both Credited and Potentially Harmful Human Actions: See Section 2.5.5.2 of reference [1] for guidance. The following is an alternative example to those offered in reference [1] that should be included during the performance of Step 5.2:

(1) The LPSD fire PRA will need to consider the potential role of the plant's alternate shutdown panel in LPSD operations. If, for example, a main control room (MCR) fire were to occur during a shutdown evolution, the analysis will need to assess what benefit could be gained through use of the alternate shutdown panel(s) to control some of the plant systems.

- Step 6: Include "Potentially High Consequence" Related Equipment:

As the final analysis step in performing Task 2, consideration is given to equipment associated with potentially high consequence events. The goal is to ensure that such events are not be prematurely screened, but are analyzed in more detail to determine their risk significance.

High consequence events for full-power conditions are potentially relevant to low-power operations as well. These are defined per Section 2.5.6 of reference [1] (list items (a) and (b) in that section). To the extent that such events are relevant to low-power operations they should be considered consistent with the full-power fire PRA guidance. In addition to (a) and (b) in reference [1], for the purposes of the LPSD fire PRA, consideration of potentially high consequence events should be extended to include events where:

(c) one or more related component failures, including spurious operations, where at least one failure/spurious operation is induced by a fire that by themselves results in fuel bundle damage either (1) when the reactor vessel and secondary containment structure are open (i.e., no primary or secondary containment) or (2) in a location outside containment to the extent that plant operations associated with the removal of fuel bundles from containment are included in the defined POS(s).

- Step 7: Assemble LPSD fire PRA component list:

As in the full-power fire PRA, the final step is to assemble the LPSD fire PRA component list. This list is generally maintained in a supporting database. The most important elements of the database will be the component identifiers and the location of the component. This effectively defines the PRA damage targets within each PAU in terms of components. Section 2.5.7 of reference [1] provides recommendations relative to the type of information that should be recorded for each item on the component list. Similar information will be needed to support the LPSD fire PRA, but this information will also need to extend to all POSs being considered. Some component characteristics (e.g., equipment identifier (ID), description, locations, system designation, and type) will remain the same regardless of the plant operating state. However, others (e.g., the normal position/status, desired position/status, failed electrical position, and failed air position) will change depending on the POS. It is recommended that the database structure be expanded to capture, as relevant, variable aspects of each component identified and the relevant entries as applicable to each identified POS. Additionally, there could be temporarily-staged equipment (e.g., auxiliary diesel), which may be a part of the safe plant operation during a POS. These new equipment items would need to be added to the list.

4.3 Task 3: Fire PRA Cable Selection

The approach and process for identifying cables of potential interest to the LPSD fire PRA is essentially identical to that applied to the full-power fire PRA as documented in Section 3 of reference [1]. However, the following clarifications should be noted:

- Any and all cables selected for inclusion in the full power fire PRA will likely be included in the LPSD fire PRA. Any exceptions to this general practice should be identified and justified.
- The cable identification process considers the equipment and components identified in Task 2 of the LPSD fire PRA rather than the set of equipment identified in the corresponding full-power fire PRA. The LPSD fire PRA equipment list may contain new components not included in the full-power fire PRA and the cable selection process should be repeated for these new components. If, as part of maintenance activities during a POS, for equipment on the component list, temporary cables are installed or existing cables are re-routed, those cables should be added to the list.
- The full-power cable selection results should also be reviewed to ensure that component failure modes that may not have been of interest to the full-power fire PRA but that have unique implications to the LPSD POSs are identified and addressed. This might, for example, include the re-introduction of cables leading to spurious equipment actuations that were considered benign in the full-power analysis but which might not be benign in the context of one or more LPSD POSs. For example, the spurious operation of valves associated only with shutdown cooling systems might have little or no impact on at-power operations, but might compromise core cooling during one or more LPSD POS. Hence, it is possible that components, and their associated cables, that were properly screened out from the at-power fire PRA would need to be added to the LPSD fire PRA equipment and cable lists.
- Cable selection considers the potential impact of cable failures in the context of each POS being considered in the LPSD fire PRA.

The final outcome of this task is a set of entries in the fire PRA Database identifying the cables of interest in terms of associated component serviced by the cable, cable function, and cable locations (see Section 3.5.6.1 of reference [1] for further detail). This information establishes the PRA damage targets in each PAU in terms of cables.

4.4 Task 4: Qualitative Screening

The purpose of this task is to qualitatively screen PAUs before the quantitative analysis is initiated. Since CDF and LERF are the focus of the LPSD fire PRA, the method and criterion provided in Chapter 4 of reference [1] are applicable to the LPSD fire PRA. The criterion provided in reference [1] is repeated here:

- Screen a PAU if the compartment does *not* contain any of the equipment (including circuits and cables) identified in Tasks 2 and 3, and
- In concert with Section 2.5.3 of the Task 2 procedure, the compartment is such that fires in the compartment will *not* impact plant status. For example, there would not be a reactor trip if the reactor is critical or loss of decay heat cooling if the reactor is in cold shutdown.

As in the case of full-power fire PRA, these criteria are specifically intended to allow the qualitative screening of PAUs that do not contain any of the equipment or cables identified in Tasks 2 and 3, but where a prolonged fire might lead operators to implement alternative or preemptive measures to maintain the POS or to place the plant in a more stable condition. That is, the full-power methodology assumes that a PAU where a fire cannot directly threaten any of the fire PRA equipment or cables will not represent a substantive contributor to fire risk even if operators might take preemptive actions to, for example, trip the plant. For this case the fire represents just one more potential source of a plant trip with no loss of mitigating equipment, scenarios already captured in the internal events PRA. Analogous situations are likely for LPSD conditions. For example, if a fire were to occur during plant startup, operators might choose to initiate a preemptive trip even though no important plant systems or equipment have been lost or are threatened. The criteria above would allow for the screening of such PAUs so long as there is no direct threat to the LPSD fire PRA equipment or cables identified as important to the POS(s) associated with plant startup.

It should be noted that compartments qualitatively screened in this task will be reexamined in Task 11 for the potential for affecting adjacent compartments in the multi-compartment fire analysis.

Compartments that would be qualitatively screened out in this task and later in Task 11 as part of the multi-compartment analysis are concluded to be of little risk significance to be tracked for risk contribution.

4.5 Task 5: Fire-Induced Risk Model

In this task the plant model is put together using event trees and fault trees for calculating the CDF and LERF of LPSD fire PRA. The same procedure as for full-power fire PRA applies here. The same modeling approaches (i.e., either fault tree linking or event trees with boundaries [1]) can be used for LPSD conditions. A separate model may need to be developed for each POS. In other words, this task may need to be repeated for each POS separately. If the *complete* set of LPSD POSs (i.e., the average or typical outages as discussed in Section 3.0 above) is of interest, a separate model should be developed for each POS of the set. Similarly, if a one-of-a-kind outage is under consideration, the model should reflect the specific conditions of that POS.

For full-power PRA model, in addition to emergency operating procedures (EOPs), the analysts may use FEPs to establish the chain of events in response to an initiating event. In the case of LPSD, practices will vary from plant to plant. Some plants may develop specialized EOPs and FEPs to address specific conditions of the POS or a one-of-a-kind outage. Those EOPs and FEPs should be consulted when developing the plant model for LPSD fire PRA (see Section 4.2.2 for further detail). If MCR evacuation is part of a fire scenario, the specific conditions of the LPSD POS should be considered when using the FEP for such events. Plant management may need to be consulted to ensure that POS specific procedures and guidelines are incorporated in the development of the LPSD fire PRA model.

Similar to full-power fire PRA, an internal events model serves as the starting point for this purpose. That is, this method assumes that an internal events LPSD PRA model for the specific POS of the study does exist. The same approach can be used as in the full-power case defined in reference [1] to arrive at the LPSD fire PRA plant model. A set of initiating events applicable to the fire analysis should be identified first and then the internal events analysis event trees and fault trees are modified as necessary to establish the set of fire-induced failures and operator errors that could lead to core damage or large early release. Similar to the full-power case, the process may include temporary changes to the Internal Events LPSD PRA that are later modified as PAUs and fire scenarios are screened from further analysis. In the temporary models, conservative measures are incorporated to expedite the analysis, which are later refined and applied to risk significant scenarios.

As noted above, the same procedure described in reference [1] applies here. The assumptions, input from other tasks and output to other tasks remain the same. When analyzing a specific POS, especially in the case of one-of-a-kind outage, it is possible that only a small part of the plant could be affected. For those cases, the analyst may elect to limit the analysis only to those parts of the plant. The same procedure should apply regardless of the scope of the analysis with the following clarifications:

- Step 1–Develop the Fire PRA CDF/CCDP Model:

  In this case the model is focused on specific LPSD POS conditions. The conditional core damage probability (CCDP) and CDF models are the same. To obtain the CCDP, the model is quantified using 1.0 for the initiating event frequency. Step 1 is divided into three sub-steps as follows:

  - Step 1.1: Select Appropriate Fire-Induced Initiating Events and Sequences and Verify Against the Component List and Failure Modes: The initiating events identified in Step 3 of Task 2 are reviewed and verified in this step. It should be noted that new initiating events (i.e., other than those adopted from the full-power fire PRA and internal events LPSD analyses) may be identified here based on the special conditions created by a specific POS.

  - Step 1.2: Incorporate Fire-Induced Equipment Failures: Equipment failure due to fire impact is carefully studied in the full-power fire PRA. The same information should apply to LPSD conditions. Clearly, special conditions should be taken into account. For example, if the doors of a normally closed active electrical cabinet are opened for the duration of a task or POS, the analyst should consider reviewing the assumptions made in the fire model for that cabinet and adjust the fire characteristics accordingly.

  - Step1.3: Incorporate Fire-Induced Human Failures: The manual actions credited in the full-power fire PRA model should be reviewed and modified to reflect the special conditions that may exist during the postulated POS. If POS specific FEPs are developed, the manual actions credited in those procedures should also be reviewed carefully and incorporated in the model.

- Step 2–Develop the Fire PRA LERF/CLERP Model:

  The same discussions apply to the LERF and conditional large early release probability (CLERP) model as in Step 1 above. Under certain POS conditions, the containment may be open to the atmosphere. In that case, the LERF model could be very simple. If the containment is closed, the analyst should develop a LERF model based on the internal events LPSD model and review and verify the applicability of equipment failures and operator actions as in the case of the CDF model.

4.6 Task 6: Fire Ignition Frequencies

4.6.1 Background Information

Similar to Task 6 of reference [1], the LPSD fire PRA should estimate fire-ignition frequencies and their respective uncertainties for ignition sources and compartments. The ignition frequency task represents the first step in quantifying fire scenarios as they are defined and analyzed in later tasks. A generic set of fire-ignition frequencies for various generic equipment types (ignition sources) typically found in certain plant locations was developed as a starting point for the full-power analysis. The same analysis approach described in Task 6 of reference [1] applies to LPSD conditions with a few exceptions as discussed below.

The frequencies provided in reference [1] were based on events that either occurred during all operating modes or just during power operation. That is, as a part of the full-power methodology development, each of the identified fire ignition source bins was reviewed. Judgment was applied to assess whether or not the frequency of fire events would be substantially dependent on the plant operating mode. Two fire frequency cases resulted as follows:

- Case 1: If the fire ignition frequency of an ignition source bin was judged to be independent of the operating mode, then the fire frequency analysis considered all fire events occurring over all plant operating states and the corresponding years of reactor experience. For these fire frequency bins, no changes are needed and the full-power fire frequency values apply to the LPSD fire PRA unchanged.
- Case 2: If the fire ignition frequency for a fire ignition source bin was judged to be dependent on the plant operating mode, then only those fire events occurring during plant power operations were considered along with the corresponding at-power reactor experience (i.e., the fraction of the time that the plants were not in power mode) in developing the full-power fire frequency estimates. For these cases, re-analysis of the fire frequency is required to support the LPSD fire PRA.

Table 1 provides the list of bins that fell into the second case. For these bins, a reanalysis of the fire frequency has been performed and LPSD-specific fire frequency values determined. Note the following:

- One event involving a gas-turbine was observed during LPSD operation that was not considered in the full-power analysis. Since the number of gas-turbines and corresponding experience base (i.e., total number of operating years) is not readily available, an ignition frequency for this bin is not estimated.
- Fires are not considered plausible inside inerted BWR containments in the full-power fire PRA. In contrast, several transient and hot work events have taken place inside BWR containments during shutdown, events not considered in the full-power analysis. Since

BWR and pressurized water reactor (PWR) containments are quite different, a new bin is defined specifically for transient and hot-work fires in BWR containments (bin 3B) and the PWR containment transient and hot-work fire bin has been renamed (bin 3P rather than simply bin 3 as in the full-power set).

Table 1: Fire Ignition Frequency Bins Specific to LPSD Conditions.

Bin #	**Location**	**Ignition Source** (Equipment Type)
2	Containment (PWR)	Reactor Coolant Pump (RCP)
3P	Containment (PWR)	Transients and Hotwork
3B	Containment (BWR)	Transients and Hotwork
5	Control/Aux/Reactor Building	Cable fires caused by welding and cutting
6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting
7	Control/Aux/Reactor Building	Transients
11	Plant-Wide Components	Cable fires caused by welding and cutting
20	Plant-Wide Components	Off-gas/Hydrogen Recombiner (BWR)
22	Plant-Wide Components	Reactor protection system (RPS) motor-generator (MG) Sets
24	Plant-Wide Components	Transient fires caused by welding and cutting
25	Plant-Wide Components	Transients
27	Transformer Yard	Transformer – Catastrophic
28	Transformer Yard	Transformer - Non Catastrophic
29	Transformer Yard	Yard transformers (Others)
31	Turbine Building	Cable fires caused by welding and cutting
32	Turbine Building	Main Feedwater Pumps
33*	Turbine Building	Turbine Generator (T/G) Exciter*
34	Turbine Building	T/G Hydrogen
35	Turbine Building	T/G Oil
36	Turbine Building	Transient fires caused by welding and cutting
37	Turbine Building	Transients

* Bin #33 frequency was not quantified assuming that under all POS conditions, the main generator would not be generating power.

As in reference [1], the combination of locations and equipment types (ignition source) are referred to here as ignition frequency bins. Table 2 provides the list of these bins and their respective generic mean frequencies (i.e., the mean value of the uncertainty distribution) in terms of the number of events per year assuming that the plant is in the specific operating mode the entire year. Table 2 is the LPSD version of the original study (i.e., Table 6-1 of reference [1]). Only those ignition frequency bins identified in Table 1 have been changed (i.e., recalculated). All of the other ignition source bins (i.e., those not in Table 1) have simply been reproduced here directly from Table 6-1 of reference [1] with no change in value.

Appendix A describes the frequency analysis approach, assumptions and derivation method. The general approach is the same as that applied to the full-power fire frequency analysis. It should be noted that proposed modifications to various ignition source bins for full-power conditions have been put forth via the NFPA-805 Frequently Asked Questions (FAQ) process (see FAQ08-0048 in the NRC Agency-wide Documents Access and Management System (ADAMS) accession number ML092190457). The FAQ proposes that a change (reduction) in fire frequencies was observed after 1990 and recalculates fire frequencies on that basis. The analysis presented in this document (i.e., in Appendix A) uses the complete set of fire event data consistent with the original treatment in NUREG/CR-6850. That is, the analysis performed here does assume that general fire frequencies dropped beginning in 1990. This approach preserves a larger event set for the LPSD-specific fire frequency bins.

There is an ongoing effort between NRC/RES and EPRI to develop an enhanced fire event database that should resolve this frequency trend issue. The analyst should be aware that a new set of fire frequencies for both full-power and LPSD conditions will likely be developed in the near future.

As with the full-power analysis, a two-stage Bayesian update method [5] was used to account for plant-to-plant variability. The 5th, 50th and 95th percentiles of the uncertainty distributions are also provided in Appendix A. As in full-power fire PRA, single stage Bayesian update methods can be used to modify the generic frequencies to reflect the influence of plant specific fire event experience.

As in reference [1], different fire types can be postulated for some of the ignition sources. For example, the bin "plant-wide components/pumps" can refer to both electric and oil fires. In those cases, Table 2 provides a split fraction for each fire type. The split fraction was determined according to fire events in the FEDB. Continuing with the plant-wide-components/pumps example, the pump fire events in the database were reviewed and classified as oil or electrical fires. This classification serves as the basis for the split fraction.

If the quantification process needs the fire frequency associated with a compartment, the following equation remains valid for the LPSD operating modes:

$$\lambda_{J,L} = \Sigma \lambda_{IS} W_L W_{IS,J,L}$$

where the right-hand side is summed over all ignition sources (IS) in compartment J of location L and where:

$\lambda_{J,L}$ = Compartment (J) level fire frequency

λ_{IS} = Plant-level fire frequency associated with ignition source IS

W_L = Location weighting factor associated with the ignition source

$W_{IS,J,L}$ = Ignition source weighting factor reflecting the quantity of the ignition source type present in compartment J of location L.

Note that the frequencies presented in Table 2 are instantaneous values that are assumed to remain constant over the POS. As presented in Section 3.0 above, the CDF calculated based on these frequencies should be adjusted for the fraction of the time that the plant is in the specific operating mode.

Plant-level fire frequencies (i.e., λ_{IS}) are either taken directly from Table 2 or can be updated using plant-specific fire experience. The location weighting factor, W_L, adjusts the frequencies for those situations where a common location (e.g. turbine building) or set of equipment types are shared between multiple units. The ignition source weighting factor, in general terms, is the fraction of an ignition source type found in a specific compartment. The discussions provided in reference [1] for these parameters apply to LPSD conditions as well.

4.6.2 Assumptions

The same set of assumptions as in reference [1] applies to LPSD fire ignition frequencies. Because of their importance, they are repeated below:

- Fire ignition frequencies remain constant over time;
- Among the plants, total ignition frequency is the same for the same equipment type, regardless of differences in the quantity and characteristics of the equipment type that may exist among the plants;
- Within each plant, the likelihood of fire ignition is the same across an equipment type. For example, pumps are assumed to have the same fire ignition frequency regardless of size, usage level, working environment, etc.
- The ignition frequency is the same among all POSs
- Clearly there are marked differences among the POSs that might influence the ignition frequencies. The level of detail provided in FEDB could not support a meaningful resolution among POSs. Therefore, one set of frequencies were estimated for all the POSs.

4.6.3 Procedure

The same procedure as in reference [1] applies to LPSD conditions. The following general conditions apply as in the full-power case:

- This task needs the list of unscreened PAUs generated in Task 4, Qualitative Screening, to establish fire frequencies by compartment.
- Fire event records available at the plant applicable to the bins defined in Table 1 may be used to update ignition frequencies of those bins using plant-specific data. (Note that it is assumed that the frequencies of the bins not included in Table 1 are already examined for plant specific fire experience and other conditions as part of the Full-power fire PRA.)

Table 2: Fire Frequency Bins and Generic Frequencies.

Bin #	Location	Ignition Source (Equipment Type)	Mode	Generic Freq (per rx yr)	Split Fraction for Fire Type					
					Electrical	Oil	Transient	Hotwork	Hydrogen	High energy arc fault (HEAF)
1	Battery Room	Batteries	All	7.5E-04	1.0	0	0	0	0	0
2	Containment (PWR)	Reactor Coolant Pump	LPSD or Undetermined	6.6E-03	0.25	0.75	0	0	0	0
3P	Containment (PWR)	Transients and Hotwork	LPSD or Undetermined	3.1E-02	0.00	0.00	0.39	0.61	0.00	0.00
3B	Containment (BWR)	Transients and Hotwork	LPSD or Undetermined	3.5E-02	0.05	0.00	0.24	0.71	0.00	0.00
4	MCR	Main Control Board (MCB)	All	2.5E-03	1.0	0	0	0	0	0
5	Control/Auxiliary/Reactor Building	Cable fires caused by welding and cutting	LPSD or Undetermined	1.2E-03	0	0	0	1.0	0	0
6	Control/Auxiliary/Reactor Building	Transient fires caused by welding and cutting	LPSD or Undetermined	9.3E-03	0	0	0.09	0.91	0	0
7	Control/Auxiliary/Reactor Building	Transients	LPSD or Undetermined	4.7E-03	0	0	1.0	0	0	0
8	Diesel Generator Room	Diesel Generators	All	2.1E-02	0.16	0.84	0	0	0	0
9	Plant-Wide Components	Air Compressor	All	2.4E-03	0.83	0.17	0	0	0	0
10	Plant-Wide Components	Battery Chargers	All	1.8E-03	1.0	0	0	0	0	0
11	Plant-Wide Components	Cable fires caused by welding and cutting	LPSD or Undetermined	8.8E-04	0	0	0	1.0	0	0
12	Plant-Wide Components	Cable Run (Self-ignited cable fires)	All	4.4E-03	1.0	0	0	0	0	0
13	Plant-Wide Components	Dryers	All	2.6E-03	0	0	1.0	0	0	0
14	Plant-Wide Components	Electric Motors	All	4.6E-03	1.0	0	0	0	0	0
15	Plant-Wide Components	Electrical Cabinets	All	4.5E-02	1.0	0	0	0	0	0

Table 2: Fire Frequency Bins and Generic Frequencies.

Bin #	Location	Ignition Source (Equipment Type)	Mode	Generic Freq (per rx yr)	Split Fraction for Fire Type					
					Electrical	Oil	Transient	Hotwork	Hydrogen	High energy arc fault (HEAF)
16	Plant-Wide Components	High Energy Arcing Faults[1]	All	1.5E-03	0	0	0	0	0	1.0
17	Plant-Wide Components	Hydrogen Tanks	All	1.7E-03	0	0	0	0	1.0	0
18	Plant-Wide Components	Junction Boxes	All	1.9E-03	1.0	0	0	0	0	0
19	Plant-Wide Components	Misc. Hydrogen Fires	All	2.5E-03	0	0	0	0	1.0	0
20	Plant-Wide Components	Off-gas/Hydrogen recombiner (BWR)	LPSD or Undetermined	2.0E-02	0.33	0	0.33	0	0.33	0
21	Plant-Wide Components	Pumps	All	2.1E-02	0.54	0.46	0	0	0	0
22	Plant-Wide Components	RPS MG sets	LPSD or Undetermined	3.2E-03	1.0	0	0	0	0	0
23a	Plant-Wide Components	Transformers (Oil filled)	All	9.9E-03	0	1.0	0	0	0	0
23b	Plant-Wide Components	Transformers (Dry)			1.0	0	0	0	0	0
24	Plant-Wide Components	Transient fires caused by welding and cutting	LPSD or Undetermined	1.1E-02	0	0	0	1.0	0	0
25	Plant-Wide Components	Transients	LPSD or Undetermined	5.8E-03	0.1	0	0.90	0	0	0
26	Plant-Wide Components	Ventilation Subsystems	All	7.4E-03	0.95	0.05	0	0	0	0
27	Transformer Yard	Transformer - catastrophic	LPSD or Undetermined	7.2E-03	0.70	0.30	0.00	0.00	0.00	0.00
28	Transformer Yard	Transformer - noncatastrophic	LPSD or Undetermined	3.8E-03	0.80	0.00	0.00	0.20	0.00	0.00
29	Transformer Yard	Yard Transformers (others)	LPSD or Undetermined	2.0E-03	1.0	0	0	0	0	0
30	Turbine Building	Boiler	All	1.1E-03	0	1.0	0	0	0	0

Table 2: Fire Frequency Bins and Generic Frequencies.

Bin #	Location	Ignition Source (Equipment Type)	Mode	Generic Freq (per rx yr)	Split Fraction for Fire Type					
					Electrical	Oil	Transient	Hotwork	Hydrogen	High energy arc fault (HEAF)
31	Turbine Building	Cable fires caused by welding and cutting	LPSD or Undetermined	1.3E-03	0	0	0	1.00	0	0
32	Turbine Building	Main feedwater pumps	LPSD or Undetermined	1.9E-03	0	1.0	0	0	0	0
33	Turbine Building	T/G exciter	At-power only	6.2E-04	1.0	0	0	0	0	0
34	Turbine Building	T/G hydrogen	LPSD or Undetermined	3.0E-03	0.25	0	0	0	0.75	0
35	Turbine Building	T/G oil	LPSD or Undetermined	2.5E-03	0	1.0	0	0	0	0
36	Turbine Building	Transient fires caused by welding and cutting	LPSD or Undetermined	2.2E-02	0.00	0.07	0.29	0.64	0.00	0.00
37	Turbine Building	Transients	LPSD or Undetermined	1.0E-02	0.00	0.04	0.96	0.00	0.00	0.00

- At least one plant or unit walkdown is recommended to identify ignition sources. In the case of LPSD, it is expected that transient and hot work related fire frequencies would be different from full-power conditions. Those parts of the plant where maintenance activities are planned may need to be examined carefully. Plant personnel involved in planning the outage may need to be consulted to establish the type and range of transient activities to establish the types of ignition sources that may be introduced in certain compartments.

As in reference [1], this task is organized around the following eight steps:

Step 1	Mapping plant ignition sources to generic sources,
Step 2	Plant fire event data collection and review,
Step 3	Plant specific updates of generic ignition frequencies,
Step 4	Mapping plant-specific locations to generic locations,
Step 5	Location weighting factors,
Step 6	Fixed fire ignition source counts,
Step 7	Ignition source weighting factors, and
Step 8	Ignition source and compartment fire frequency evaluation.

These steps are further discussed below:

- Step 1: Mapping Plant Ignition Sources to Generic Sources

  This step should already be completed as part of the full-power fire PRA. That is, the characteristics of fixed ignition sources in the plant should not change based on POS in the context of this step. If any new plant locations have been added to the LPSD study, then some additional mapping may be required. It is recommended that any temporary ignition sources introduced during LPSD be treated as transient fire sources rather than as fixed fire sources.

- Step 2: Plant Fire Event Data Collection and Review

  For fire event data collection and review, the same approach as that presented in reference [1] can be followed for LPSD operating modes. In this case the fire events that had occurred during LPSD operating modes are collected and analyzed. The same two questions, as in full-power case apply here:

  (1) Are there any unusual fire occurrence patterns in the plant?

  (2) Is plant-specific fire frequency evaluation warranted?

  Guidance provided in reference [1] on determining the response to these two questions applies to LPSD operating modes as well.

- Step 3: Plant Specific Updates of Generic Ignition Frequencies

  As in reference [1], this step should be followed for those frequencies that will be based on plant-specific fire event data. The approach described in reference [1] applies here with the exception of one minor difference. The generic bin frequencies can be updated using a Bayesian approach [5] that includes Poisson distribution for the likelihood function of plant specific fire events. The Poisson distribution requires number of reactor years (T). In the case of LPSD operating modes, this should be the total time that the affected unit has been in LPSD operating modes since commercial operation (i.e., "reactor-in-LPSD-years" rather than "reactor-at-full-power-years.").

- Step 4: Mapping Plant-Specific Locations to Generic Locations

The location mapping of the full-power fire PRA should be validated for LPSD specific conditions. For example, in the case of the BWRs, the containment may need to be added to the list because maintenance work may be scheduled inside the containment.

- Step 5: Location Weighting Factor

Plant configuration may be reviewed to verify that changes planned for LPSD conditions do not affect W_L. For example, if Unit 1 is shutdown with several systems under maintenance and part of Unit 2 systems are used to provide the necessary functions, the fire PRA analyst may need to include parts of Unit 2 in the Unit 1 analysis. In such a case, the analyst should define the method for counting ignition sources carefully so that relevant compartments and ignition sources from Unit 2 can be correctly included in the Unit 1 LPSD fire PRA. To further expand this example, consider 10 pumps in Units 1 and 2 each and two of the Unit 2 pumps are being used for Unit 1 service during a specific LPSD operating mode. Also, consider that those two pumps are located in the same compartment, J, with 3 other Unit 2 pumps (total of 5 pumps). The fire ignition frequency in that compartment associated with pump operation would then be calculated by the following equation:

$$\lambda_{J,\,pump} = \lambda_{bin\ 21} \text{ x } W_{IS,\,J,\,L} \text{ x } W_L$$

where:

$\lambda_{bin\ 21} = 2.1\text{E-}02$ per reactor year, frequency of a fire from any one of the pumps in one of the two units.

$W_{IS,\,J,\,L} = 5/20$ Fraction of the pumps present in this room with respect to all the pumps in the two units

$W_L = 2$ The correction factor for counting both units in the total pump count

- Step 6: Fixed Fire Ignition Source Counts:

To estimate the frequency of fire occurrence per ignition source or per compartment, it is necessary to obtain the total number of items within a unit that belong to each bin. The counting approaches recommended in reference [1] augmented by responses to the FAQs generated after the publication of reference [1] should apply to LPSD operating modes. Generally, the number of countable items (e.g. pumps and electrical cabinets) should remain the same between full-power and LPSD conditions. However, for those bins for which LPSD specific ignition frequencies are established, the analyst should review the equipment configurations during LPSD conditions to verify that full-power counts remain valid. Transients and hot work related ignition source weighting factors could be different during LPSD operating modes, which is discussed as part of Step 7 below.

- Step 7: Ignition Source Weighting Factors:

The Ignition source weighting factor, $W_{IS,J,L}$, is the fraction of ignition source (IS) that is present in compartment J. The $W_{IS,J,L}$ are evaluated for all the ignition sources identified in Step 1 of this task and all the compartments identified in Task 1. The bins listed in the preceding section can be classified in three categories: countable items, transients, and large systems. The procedure presented in reference [1] for all three types of items should apply to LPSD operating modes.

It is anticipated that the relative likelihood of transient and hot-work related fires in various plant locations will shift during LPSD operations as compared to full-power operation and the analysis should account for these differences. Transient combustible controls programs may be relaxed or may allow for routine exemptions to the normal controls. Transient materials not expected to be found during full-power operations (e.g., larger quantities of grease or oil and various equipment packing materials) may be introduced into the plant given that a range of longer-term maintenance activities will be undertaken. Hot work (e.g., welding and cutting) may be allowed in locations where that type of work would normally be disallowed during power operations. Plant traffic and occupancy factors would also be different.

As a result, for the ignition source bins related to "general transients" (i.e., bins 3A, 3B, 7, 25 and 37), "transient fires caused by welding and cutting" (i.e., bins 6, 24, and 36) and "cable fires caused by welding and cutting" (i.e., bins 5, 11 and 31) the influencing factors assigned to each compartment should be adjusted to reflect the specific LPSD conditions. This will require updating of the location-specific frequencies accordingly. For example, for those compartments where maintenance work is planned, "very high" may be assigned to the maintenance factor. For the passageways that lead to that compartment, the occupancy factor could be "high" as well.

- Step 8: Ignition Source and Compartment Fire Frequency

Fire frequencies (generic or plant-specific) for a single fire ignition source, $\lambda_{IS\text{-}J}$, and fire frequencies for an entire PAU (i.e., considering the combined frequency for all ignition sources in the PAU) are calculated using the same process as was described in reference [1].

4.7 Task 7: Quantitative Screening

The objective of this task is to apply quantitative screening criteria to reduce the list of PAUs and fire scenarios carried forward for detailed analysis. This is an important task used commonly in fire PRA to limit the level of effort and yet maintain the integrity of the analysis. Screening does not imply *removing* a PAU or fire scenario from the analysis. Rather screening simply implies that no further analysis effort (e.g., to increase the level of analysis detail) will be expended on that scenario or PAU. The CDF and LERF of the screened PAU or scenario would be based on the existing level of detail (a screening result) and the risk contribution would be ranked among all other PAUs and fire scenarios on that basis.

For full-power PRA, screening criteria are defined in reference [1] for CDF, LERF, incremental core damage probability (ICDP) and incremental large early release probability (ILERP). The same criteria may be used for LPSD fire PRA. For ease of reference, the criteria presented in reference [1] are repeated here in Tables 3 and 4. Note that the quantitative measures (e.g., CDF) are expressed in reactor years, which means that they *include the fraction of time that the plant is in the postulated POS*.

The criteria presented in Tables 3 and 4 may be met by reducing the duration of a POS. One then may argue that defense in depth can be reduced significantly while meeting the screening criteria. Defense in depth related and all other regulatory requirements remain in effect during a POS. The PRA provides a measure to establish the overall risk and relative ranking of various contributors that can be used to determine if added risk reduction measures are necessary and where those measures can be most effective.

It should be noted that these are suggested screening criteria. Also note that the cumulative screening criteria presented in Table 4 compare the LPSD fire PRA to the corresponding internal events LPSD analysis results on a POS by POS basis. This approach is intended, in part, to maintain consistency with this document's neutrality relative to how the POSs to be analyzed are defined, and in particular, with how complete the POS set is. This screening approach works equally well whether the analysis quantifies a complete set of very specific POSs, quantifies a generally defined set of average outage conditions, or quantifies just one POS. Moreover, if a large number of compartments or fire scenarios meet the criteria in Table 3, it may not be possible to meet the criteria presented in Table 4. The analyst may encounter this situation after a few screening phases. To meet Table 4 criteria, the analyst may need to adjust Table 3 criteria downward (make the criteria more stringent).

Table 3: Quantitative Screening Criteria for Single PAU Analysis.

Quantification Type	**CDF and LERF Compartment Screening Criteria**	**ICDP and ILERP Compartment Screening Criteria (Optional)**
PAU CDF	CDF < 1.0E-07/year* *Note: This criterion should be reduced, as necessary, to ensure that the CDF criterion in Table 4 is met.*	
PAU CDF with Intact Trains/Systems Unavailable		ICDP < 1.0E-7 *Note: This criterion should be reduced, as necessary, to ensure that the ICDP criterion in Table 4 is met*
PAU LERF	LERF < 1.0E-08/year* *Note: This criterion should be reduced, as necessary, to ensure that the LERF criterion in Table 4 is met*	
PAU LERF with Intact Trains/Systems Unavailable		ILERP < 1.0E-8 *Note: This criterion should be reduced, as necessary, to ensure that the ILERP criterion in Table 4 is met*

* All quantitative measures include the fraction of time that the plant is in the postulated POS.

Table 4: Quantitative Screening Criteria for All Screened PAUs.

Quantification Type	**Screening Criteria**
Sum of CDFs for all screened out PAUs for each POS analyzed	< 0.1 * [Internal Event CDF for the same POS]
Sum of LERFs for all screened out PAUs for each POS analyzed	< 0.1 * [Internal Event LERF for the same POS]
Sum of ICDPs for all screened out PAUs for each POS analyzed	< 1.0E-06
Sum of ILERPs for all screened out PAUs for each POS analyzed	< 1.0E-07

As in reference [1], it should be emphasized that the screening criteria are meant to be applied as part of the fire PRA Model building and quantifying process. The screening criteria are not the same, nor should they be confused with the acceptance criteria for applications of PRA. For example, the screening criteria herein are not directly correlated to the delta-CDF and delta-LERF criteria used in Regulatory Guide 1.174 [6] for the acceptability of making permanent changes to the plant. The screening criteria are intended to complement the Regulatory Guide (RG) 1.174 criteria and to allow for the use of fire PRA results in a RG 1.174 application, but they are also intended to serve the broader objectives of a typical fire PRA.

The overall approach described in reference [1] is applicable to LPSD conditions. The same assumptions and input and output discussions apply here as well. Several stages of quantitative screening are expected to be necessary to identify plant areas that need detailed analysis and establish risk ranking of PAUs and fire scenarios. Four phases of quantitative screening are identified in reference [1] (Tasks 7A through 7D) based on implementation of Tasks 8 through 10 of the methodology. The same phases may be used in LPSD fire PRA. Clearly, conducting a screening phase would depend on the analyst's preferences and the results of each task (i.e., Tasks 8 through 10).

- Step 1–Quantify CDF Model:

  The model developed in Task 5 is quantified in this step. The CCDP is quantified first followed by CDF. This step involves 3 sub-steps as follows.

  - Step 1.1: Quantify CCDP Model: The CCDP is calculated by setting the fire scenario frequency as 1.0 per reactor year. Event trees and fault trees are quantified using internal events failure probabilities and human error probabilities (HEPs) estimated in Task 12. In the initial stages of screening, the circuit failure probabilities may be set at 1.0 and screening HEPs may be used (see Task 12). In later stages of screening, more refined values may be used. The outcome of this step is a list of PAUs and fire scenarios organized by CCDP. This result provides an important insight into fire risk significance of a PAU or scenario.

  - Step 1.2: Quantify CDFs: CDF results can be calculated for a single fire scenario, for a group of fire scenarios (e.g., a group of electrical cabinets), for a PAU, or for the entire plant. Quantitative screening is generally based at the fire scenarios and/or PAU level. For quantification, the fire frequency is matched to the screening level applied (e.g., fire frequency might reflect a single fire source, a group of fire sources, or an entire PAU). The CDF of a specific POS is calculated using the following equation (from Section 3.0 above):

$$CDF_{POS(i)} = CDFPOS(i) \text{ x } ft_{POS(i)}$$

Where:

$$CDF_{POS(i)} = \lambda_{fire} \text{ x } CCDP_{POS(i)}$$

λ_{fire} = The fire frequency of the PAU or fire scenario (depending on screening level being applied) from Task 6 or Task 11 per reactor year.

$CCDP_{POS(i)}$ = The CCDP of POS(i) calculated in Step 1.1 above.

The fraction of time that POS(i) is in effect (i.e., $ft_{POS(i)}$) is estimated in this step and used in CDF calculation.

In the first quantitative screening stage, the frequency (i.e., λ_{fire}) would be gleaned from Task 6 where fire frequencies are estimated at the PAU level. At later stages of analysis, the refined fire frequency calculated in Task 11 is used. By applying the screening criteria discussed above, PAUs or fire scenarios are set aside from further analysis.

- Step 1.3: Quantify ICDP Values (Optional): This is an optional task that may not be applicable to LPSD conditions since Limiting Conditions of Operation (LCOs) may not be applicable. The same approach may be used as in reference [1] to define and calculate ICDP values.

- Step 2–Quantify LERF Model:

The same formulations and process as for CDF can be used to establish the LERF for each PAU or fire scenario. Similar to Step 1, this step is defined in three substeps where CLERP is calculated first. Similar to CDF, LERF is calculated as the product of CLERP, fire frequency (i.e., λ_{fire}) and fraction of time POS is in effect (i.e., $ft_{POS(i)}$).

- Step 3–Quantitative Screening:

In this step, the CDF, LERF, ICDP (optional), and ILERP (optional) values are compared against the quantitative screening criteria provided in Tables 3 and 4. PAUs and fire scenarios that fall below the screening criteria are screened out from further analysis but retained for overall risk quantification and risk ranking of significant contributors. As this screening task progresses, the analyst may have to reduce the criteria presented in Table 3 to allow the results to meet Table 4 criteria.

4.8 Task 8: Scoping Fire Modeling

4.8.1 General Discussion

Scoping fire modeling is the first task where computational fire modeling tools are used to identify those fixed ignition sources that may impact the fire risk of the plant. Note that transient related ignition sources are not examined in this task. Screening some of the fixed ignition sources, along with the application of severity factors to the unscreened ones, may reduce the compartment fire frequency previously calculated in Task 6.

The process for completing the LPSD fire PRA Scoping Fire Modeling Task is fundamentally the same as the full power analysis described in reference [1]. The analysis considers the potential for each fire ignition source to induce either fire spread to secondary combustibles or damage to PRA targets (equipment and cables) without fire spread.

For this task, the analyst may, in fact, be able to draw upon results obtained in the full-power fire PRA to a large extent. The nature of the fires associated with fixed fire sources may be independent of the plant operating mode. The nature and proximity of fixed secondary combustibles are also unlikely to change. The primary challenge may lie in two areas; namely, changes to the nature or location of PRA targets and potential changes to the configuration or characteristics of certain types of fixed fire ignition sources.

In the case of PRA targets, several factors could change the relationship between ignition source and target. LPSD fire PRA targets may exist in locations that do not contain full-power fire PRA targets. The damage targets of concern may also change depending on the POS being analyzed, so the analysis needs to either bound all POSs or consider each POS separately. Damage targets may also be of a different type than were considered in the full-power analysis (e.g., a different type of cable or presence of electronic equipment rather than cables as the most easily damaged target).

The second factor that should be considered is the possibility of altered conditions of a fixed ignition source. Altered conditions may lead to a fire more severe than the most severe conditions postulated in full-power analysis for a given ignition source. For example, an electrical cabinet that is normally fully enclosed during full-power operations may be operated with the doors open during a specific POS (e.g., to allow for maintenance or monitoring activities). Opening the cabinet door increases the potential fire intensity and the potential for fire spread outside the cabinet. This could, in turn, affect other aspects of the fire scenario including time to detection and time to fire damage.

4.8.2 Crediting Equipment Operational Status

Altered equipment conditions might also effectively preclude specific types of fires with certain types of ignition sources. For example, a bus duct that has been de-energized during a particular POS cannot act as a source of a high energy arc fault (HEAF) and fire. Other types of equipment that are fully shut down during specific POSs might also preclude, or sharply limit, certain types of fires. For example, an electrical motor fire would not be considered plausible for a motor that is never energized during a particular POS because it is the electric potential that creates the fire hazard.

Whether or not special treatment is warranted for de-energized or non-operating equipment should be determined on a case-specific basis. That is, the analyst should make the argument for elimination or modification of a specific fire ignition source (or a specific type of fire for a given fire ignition source; e.g., electrical fires for a pump) based on the plant configuration and equipment status. The results could then be factored into the scoping fire modeling analysis by incorporating the modified fire characteristics or by screening out the fire source.

There is a substantive difference between full-power and LPSD conditions that impacts the viability of this approach. For the full-power fire PRA, de-energizing plant equipment is not considered as a mitigating factor in the potential for fires to occur [1] largely because the analysis should span all potential operating configurations which could include swapping of active and standby equipment trains. Demonstrating that a specific set of equipment would never be operated or energized during power operations is quite difficult for most of the equipment of interest. The approach is more viable for LPSD plant operations because a broader range of plant equipment will be deenergized and non-operational during certain POSs. For example, unless the plant is actively generating electric power, the turbine generator exciter will not be active, the turbine lube oil system will not be pressurized, and the iso-phase bus duct will be deenergized. For various LPSD POSs, a broad range of reactor systems will be shut down and non-operational (e.g., high pressure flow and inventory control systems during refueling).

As a result, LPSD conditions present a greater opportunity to credit equipment status as a factor in fire likelihood because it will be easier to demonstrate that certain equipment will, in fact, be non-operational and/or deenergized. This is especially true and potentially advantageous for analyses built on a foundation of specific POSs able to deal with specific equipment line-ups. For a detailed outage-specific approach, the analysis could include consideration of the fire potential of equipment based on whether or not that equipment is energized and/or operating (e.g., whether or not electrical potentials are present or whether or not oil systems are pressurized). If the analysis is based on an *average POS* approach, it will be more difficult to argue that certain types of equipment will never be energized. In particular, the analysis would likely not be able to take advantage of train outages for LPSD equipment, but might still take advantage of the shutdown of other equipment exclusively associated with power operations (e.g., BOP equipment).

Specific potential considerations in this regard are as follows:

- Portions of a circuit that are isolated from electric power during a particular POS would not be subject to electrical fires. Note that consideration should be given to both power circuits and control circuits. As an example, even if a switchgear breaker is “racked out,” if control power remains available, a potential for electrical fires also remains.[5] However, a switchgear breaker that is “racked out” would deenergize the power circuits and cables fed by that breaker eliminating the potential for electrical fires in the downstream power circuits.

- Some lubrication systems may be depressurized during various LPSD POSs. No specific analysis of oil fires in pressurized versus non-pressurized systems has been conducted so it is not possible to speculate on the impact of system pressurization on fire frequencies. Note that for some specific cases LPSD specific fire frequencies have been calculated (i.e., main feedwater pump oil fires and turbine generator lube oil fires) while other cases assume the same fire frequency for all modes of plant operation. In general, two types of oil fires are possible; namely, oil spills burning as a pool fire and pressure-driven oil spray fires. For a normally pressurized oil system that is de-pressurized during LPSD conditions, the potential for an oil spray fire becomes localized to system elements subject to a static pressure head (e.g., leaks at a low-elevation outlet valve on a storage tank). For locations not subject to a static pressure head, a spill consistent with leakage from a non-pressurized system should be assumed. It is common practice to locate oil

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[5] Note that non-operational equipment might still be vulnerable to fire-induced spurious actuation, but this would be a potential consequence of a fire involving some other fire ignition source and not a factor that would contribute to the potential for fire ignition.

reservoirs at a relatively low point in the system so much of the system piping for a normally pressurized system will likely be at or near atmospheric conditions when the system is de-pressurized. Some system elements may also be drained of oil. For locations that retain oil, a reduced pressure would also impact potential leak rates. A review of any oil fire scenarios postulated in the full-power fire PRA is recommended to ensure that the assumed fire conditions and characteristics are consistent with the actual status of the lubricating system.

In general, most aspects of the ignition frequency analysis need not be revisited. In particular, de-energized equipment would not need to be removed from the equipment type counts in Task 6 in order to take advantage of these approaches. This recommendation is based on the notion that the Task 6 approach to estimating ignition frequencies inherently reflects the fact that any given piece of equipment will cycle through periods of both in and out of service times. The method does not attempt to estimate, for example, pump operating years but rather uses reactor years as the frequency basis. In the specific case of the LPSD analysis, specific equipment line-ups are likely based on the POS definition, and it would be appropriate to reflect a known line-up to the extent feasible in the risk evaluation.

Beyond these possible modifications, the general task objectives and approach for Task 8 remain the same for LPSD fire PRA**.** The only differences are applied in Table 5 (modified version of Table 8-1 of reference [1]) where one new bin is introduced: 3A, Containment PWR. Table 5 emphasizes the ignition sources that can and cannot be screened out in this task. Note again that this task focuses only on fixed ignition sources.

4.9 Task 9: Detailed Circuit Failure Analysis

This is the second phase of circuit analysis where circuit operation and functionality are examined to determine equipment responses to specific cable failure modes. These relationships are then used to further refine the original cable selection by screening out cables that cannot prevent a component from completing its credited function. The approach presented in reference [1] should also apply to LPSD conditions. Since control circuits are not generally altered during any LPSD POS, it is anticipated that the analysis done and information generated as part of full-power fire PRA would also be applicable to LPSD conditions. However, it is recommended that as in Task 3, the information obtained from full-power fire PRA be reviewed carefully to verify that it is applicable to the specific conditions imposed by the postulated LPSD POS(s).

In an LPSD fire PRA additional circuits may be identified needing a detailed analysis. The same methodology as that described in Chapter 9 of reference [1] can be applied here to conduct that analysis. This includes adding the new information to the circuit failure data base created as part of full-power fire PRA.

As in full-power fire PRA, the output of this task supports the quantitative screening process under Task 7.

Table 5: Zone of Influence (ZOI) and Severity Factor Recommendations.

ID	Location	Ignition Source	Ignition Source Screening Approach	Recommended Method(1)
1	Battery Room	Batteries	Calculate ZOI using Figure F-2 in [1]	Electric motors
2	Containment (PWR)	Reactor coolant pump	Do not screen in Task 8	Assume 1.0
3P	Containment (PWR)	Transients and hotwork	Do not screen in Task 8	Assume 1.0
3B	Containment (BWR)	Transients and hotwork	Do not screen in Task 8	Assume 1.0
4	MCR	Electrical cabinets	Calculate ZOI using Figure F-2 in [1]	Applicable electrical cabinet
5	Control/Auxiliary/Reactor Building	Cable fires caused by welding and cutting	Do not screen in Task 8	Assume 1.0
6	Control/Auxiliary/Reactor Building	Transient fires caused by welding and cutting	Do not screen in Task 8	Assume 1.0
7	Control/Auxiliary/Reactor Building	Transients	Do not screen in Task 8	Assume 1.0
8	Diesel Generator Room	Diesel generators	Do not screen in Task 8	Assume 1.0
9	Plant-Wide Components	Air compressors	Do not screen in Task 8	Assume 1.0
10	Plant-Wide Components	Battery chargers	Calculate ZOI using Figure F-2 in [1]	Electrical cabinets
11	Plant-Wide Components	Cable fires caused by welding and cutting	Do not screen in Task 8	Assume 1.0
12	Plant-Wide Components	Cable run (self-ignited cable fires)	Do not screen in Task 8	Assume 1.0
13	Plant-Wide Components	Dryers	Calculate ZOI using Figure F-2 in [1]	Transients

Table 5: Zone of Influence (ZOI) and Severity Factor Recommendations.

ID	Location	Ignition Source	Ignition Source Screening	Recommended Method[1]
14	Plant-Wide Components	Electric motors	Calculate ZOI using Figure F-2 in [1]	Electric motors
15	Plant-Wide Components	Electrical cabinets	Calculate ZOI using Figure F-2 in [1]	Electrical cabinets
16	Plant-Wide Components	High-energy arcing faults	Do not screen in Task 8	Assume 1.0
17	Plant-Wide Components	Hydrogen tanks	Do not screen in Task 8	Assume 1.0
18	Plant-Wide Components	Junction box	Calculate ZOI using Figure F-2 in [1]	Electric motors
19	Plant-Wide Components	Miscellaneous hydrogen fires	Do not screen in Task 8	Assume 1.0
20	Plant-Wide Components	Off-gas/Hydrogen recombiner (BWR)	Do not screen in Task 8	Assume 1.0
21	Plant-Wide Components	Pumps	Do not screen in Task 8	Assume 1.0
22	Plant-Wide Components	RPS MG sets	Calculate ZOI using Figure F-2 in [1]	Electric motors
23a	Plant-Wide Components	Transformers (oil filled)	Do not screen in Task 8	Assume 1.0
23b	Plant-Wide Components	Transformers (dry)	Calculate ZOI using Figure F-2 in [1]	Electric motors
24	Plant-Wide Components	Transient fires caused by welding and cutting	Do not screen in Task 8	Assume 1.0
25	Plant-Wide Components	Transients	Do not screen in Task 8	Assume 1.0
26	Plant-Wide Components	Ventilation subsystems	Calculate ZOI using Figure F-2 in [1]	Assume 1.0
27	Transformer Yard	Transformer - catastrophic	Do not screen in Task 8	Assume 1.0
28	Transformer Yard	Transformer - noncatastrophic	Do not screen in Task 8	Assume 1.0

Table 5: Zone of Influence (ZOI) and Severity Factor Recommendations.

ID	Location	Ignition Source	Ignition Source Screening	Recommended Method(1)
29	Transformer Yard	Yard transformers (Others)	Do not screen in Task 8	Assume 1.0
30	Turbine Building	Boiler	Do not screen in Task 8	Assume 1.0
31	Turbine Building	Cable fires caused by welding and cutting	Do not screen in Task 8	Assume 1.0
32	Turbine Building	Main feedwater pumps	Do not screen in Task 8	Assume 1.0
33	Turbine Building	T/G exciter	Not considered for non-power POSs	
34	Turbine Building	T/G hydrogen	Do not screen in Task 8	Assume 1.0
35	Turbine Building	T/G oil	Do not screen in Task 8	Assume 1.0
36	Turbine Building	Transient fires caused by welding and cutting	Do not screen in Task 8	Assume 1.0
37	Turbine Building	Transients	Do not screen in Task 8	

Table Notes:

(1) This column provides a recommended approach for establishing the probability distribution for severity factor. See Appendix E of reference [1] and related responses to the FAQs that appeared after publication of reference [1].

4.10 Task 10: Circuit Failure Mode Likelihood Analysis

The purpose of this task is to estimate the failure mode probabilities of circuits that are identified in the previous tasks for further analysis. As noted in reference [1], the methods and data for deriving circuit failure probabilities are based on limited information and the field continues to evolve. The analyst is encouraged to use the latest information, if this task is included in an LPSD fire PRA.

There is no reason to conclude that the methods and underlying test data used for estimating circuit failure probabilities should be different between full-power and LPSD POS conditions. Therefore, the discussions provided in Chapter 10 of reference [1] should apply to LPSD conditions as well. The assumptions provided in Section 10.3.2 of reference [1] are also applicable to LPSD conditions, except that some of the circuits may be de-energized during a specific POS.

It is anticipated that the majority of circuits that would be identified in Task 9 of LPSD fire PRA for further analysis would have already been addressed in the full-power fire PRA. It is recommended that the existing analyses be reviewed to ensure that all underlying assumptions remain valid under the specific conditions of the LPSD POS. For example, if the analyst adjusted a probability value because of special conditions affecting a cable, the LPSD analysis should confirm that those special conditions remain valid during the postulated POS.

4.11 Task 11: Detailed Fire Modeling

4.11.1 Purpose and Scope

Detailed fire modeling provides the final estimates for the frequency of occurrence of fire scenarios involving a specific fire ignition source failing a predefined target set before fire protection succeeds in protecting this target set. This result is combined in the final quantification steps that follow this task, with the CCDP/CLERP given failure of the target set to estimate the CDF/LERF contribution for each fire scenario. The CCDP/CLERP may include modified human error probabilities based on fire scenario specifics.

The detailed fire modeling process generally follows a common structure, but the details of the analyses often vary depending on the specifics of the postulated fire scenario. This chapter addresses three general categories of fire scenarios: fires affecting target sets located inside one compartment; fires affecting the main control room (MCR); and fires affecting target sets located in more than one PAU (multi-compartment fire analysis).

For LPSD fire PRA, the detailed fire modeling process is generally the same as the RES/EPRI full-power fire PRA methodology in reference [1]. The same input and output information applies. Focused walkdowns are an important part of this task. The supporting information provided in the Appendices of reference [1] is also applicable[6]. Clearly, the analyst should use the latest information applicable to each scenario analysis. Though the general fire modeling

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[6] Note that some aspects of various fire modeling approaches have been modified or amended based on feedback from the NFPA-805 pilot plant applications. Modifications documented via the NFPA implementation FAQ process are considered equally applicable to the LPSD fire PRA.

approach and process is essentially unchanged between LPSD and full-power, the plant configuration will impact the choice of fire scenario damage targets, and may alter the relationship between fire source and damage targets (e.g., relative locations, damage thresholds, and intervening combustibles). These changes could in turn alter the objectives and results of the detailed fire modeling task. Therefore, to the extent that fire source and target relationships change, fire modeling analyses may need to be repeated for different POSs to ensure that all POS specific factors are incorporated and evaluated.

A detailed fire modeling analysis may be performed for each fire scenario in each unscreened PAU, with the focus placed on those fire scenarios with the highest contribution to the CDF/LERF. For many compartments, it may be appropriate to develop several fire scenarios in order to appropriately represent the range of unscreened fire ignition sources (i.e., ignition sources that were not screened in Task 8). Detailed fire modeling may utilize a range of tools to assess fire growth and damage behavior and the fire detection and suppression response for specific fire scenarios. These tools include computational fire models, statistical models, and empirical models.

The ultimate output of Task 11 is a set of fire scenarios, each including:

- a defined fire ignition source;
- a defined target set consisting of those LPSD fire PRA components and cables that are subject to fire-induced damage given ignition of the fire ignition source;
- an estimate of the frequency of fires involving the defined fire ignition source leading to loss of the defined target set (including the fire ignition frequency, applicable severity factors, and corresponding non-suppression probability values); and
- an examination of forced abandonment scenarios involving fire in the MCR or in other plant areas that could lead to MCR abandonment (i.e., due to loss of MCR functions).

4.11.2 General Approach.

The general approach to fire scenario modeling remains the same for the LPSD fire PRA as in the full-power fire PRA [1]. Figure 2 provides a block diagram of the overall process. Note that the step definitions are the same as those cited in reference [1]. Clearly, the special conditions of each POS should be taken into account when conducting each step, but the nature and objectives of each step remain unchanged.

The factors that may require special consideration for the LPSD fire PRA include the following:

- For certain POSs, the status of compartment boundaries could be significantly different from full-power conditions. For example, during a maintenance outage certain doors that are normally closed may be propped open by temporary piping and cables passing through the doorway, penetrations may be un-sealed to allow for cable or piping work, equipment hatches may be removed, and/or the containment structure may be open.
- As noted with regard to scoping fire modeling (Task 8), the characteristics of an ignition source may be altered. For example, cabinet doors may be opened whereas they are normally closed.

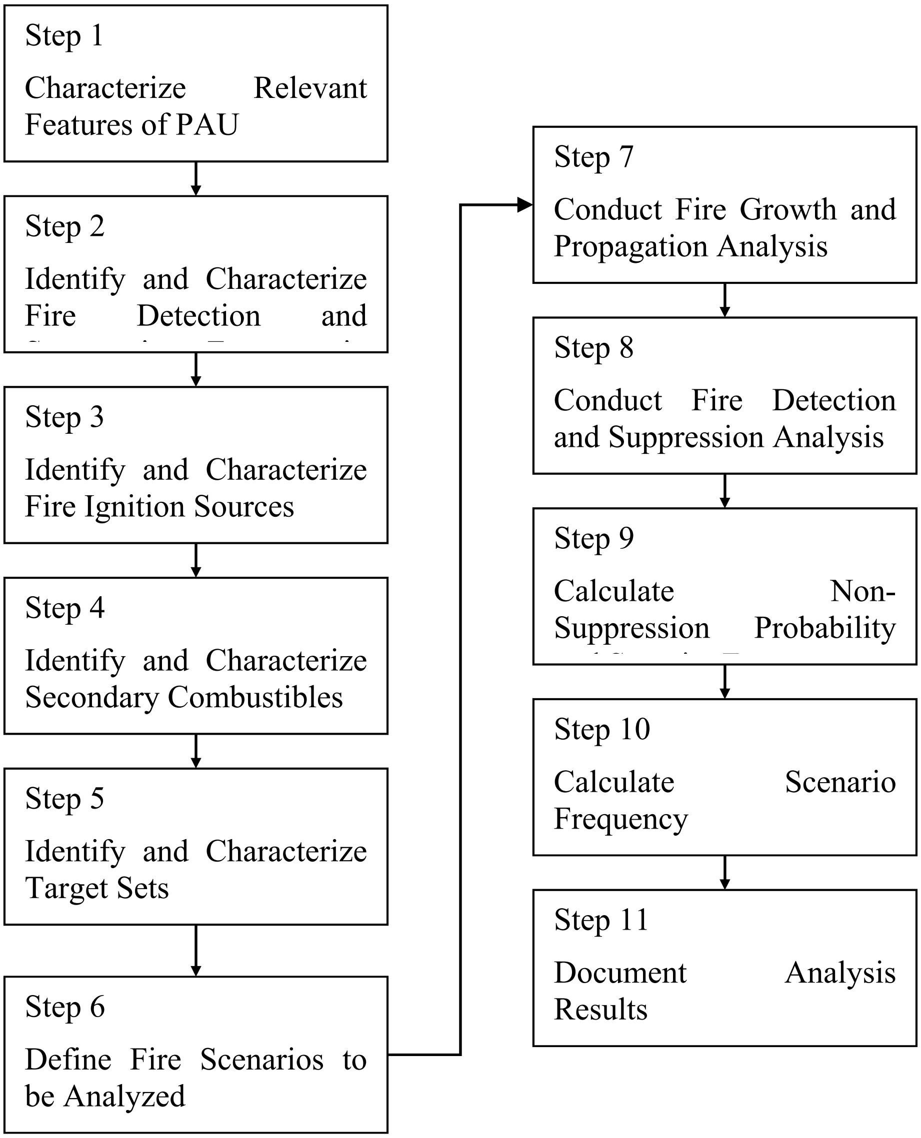

Figure 2: General Analysis Flow Chart for Task 11 – Detailed Fire Modeling.

- The status of fire detection and suppression systems could be altered. For example, fire protection systems may be unavailable due to maintenance or may be intentionally disabled due to other maintenance activities under way in the protected space (e.g., to prevent spurious actuation).
- Fire brigade access paths may be altered because of maintenance or plant upgrade activities.

- New transient combustibles may be present in a compartment. For example, packing materials for new or replacement equipment may be introduced, combustible controls restrictions for specific areas may be relaxed, pump oils may be changed out so that a larger quantity of oil than might normally be present is introduced into an area (e.g., both the old oil and new replacement oil loads may be present and exposed), and/or combustible cutting oil may be brought into a compartment for certain repair or modification work.
- Welding and cutting operations may be undertaken in areas where such activities would be either prohibited or very unlikely during at-power operations (e.g., the MCR, cable spreading room, cable vault and tunnel areas, emergency switchgear rooms, etc.).
- Staffing changes could alter fire watches and other general personnel traffic and occupancy patterns. For example, compensatory measure fire watches may be suspended or a space that is not routinely manned during power operations may be manned during a specific POS.
- The containment structure may be open with substantive work activities underway. In particular, for BWRs with inerted containment, de-inerting of the containment introduces a potential for fires in areas never considered in the full-power fire PRA.

The approach for addressing these issues is exactly the same as that described in reference [1]. The analyst should simply gather and apply the appropriate data to support the analysis for the POS of interest. Table 6 provides a list of the ignition sources and recommended severity factor and suppression curves. There are relatively few differences between the information provided in Table 6 and that provided in reference [1]. It should be noted that, as discussed below, the manual suppression curves may need to be adjusted to reflect the specific conditions of a POS. The available LPSD suppression data were not sufficient to support a statistical analysis of the LPSD versus full-power suppression timing. Hence, it is recommended that a judgment-based adjustment be applied to address the specific plant conditions and changes as compared to full power conditions. That is, it may not be possible to fully characterize those aspects of the fire scenarios that would impact manual fire fighting and suppression reliability. The characteristics of interest (e.g., fire watches, location accessibility, fire fighting system outages, staffing levels, etc.) might vary over the course of a given POS, from POS to POS, or from outage to outage. Hence, the recommended approach is to apply judgment based adjustments to, for example, reflect the possibility that an area might be manned at the time of the fire increasing the likelihood of rapid detection and suppression or, conversely, that ongoing work may interfere with fire fighters reaching the scene and thereby delay the response.

4.11.3 Assumptions

The same assumptions apply to LPSD fire scenario analyses as in the full-power fire PRA [1]. The key assumptions are repeated below:

- The analysis is limited to considering a single fire occurring at any given time.
- If a fixed, water-based fire suppression system is available, actuation of that system is assumed to disrupt the process of fire growth and spread sufficient to achieve and maintain effective control of the fire so that additional damage to potential fire PRA targets will not occur.

Table 6: Recommended Severity Factors and Suppression Curves for Ignition Sources in the Frequency Model.

ID	Location	Ignition Source	Heat Release Rate (HRR) Probability Distribution for Calculation of Severity Factor	Suppression Curve
1	Battery Room	Batteries	Electric motors	Electrical
2	Containment (PWR)	Reactor coolant Pump	Pumps (Electrical)/Oil spills	Containment
3P	Containment (PWR)	Transients and hotwork	Transients	Containment
3B	Containment (BWR)	Transients and hotwork	Transients	Containment
4a	MCR	Electrical cabinets	Applicable electrical cabinet	MCR
4b	MCR	MCB	See Appendix L of [1]	See Appendix L of [1]
5	Control/Auxiliary/Reactor Building	Cable fires caused by welding and cutting	See Appendix R of [1]	Welding
6	Control/Auxiliary/Reactor Building	Transient fires caused by welding and cutting	Transients	Welding
7	Control/Auxiliary/Reactor Building	Transients	Transients	Transients
8	Diesel Generator Room	Diesel generators	Oil spills	Electrical/Oil
9	Plant-Wide Components	Air compressors	Electrical/Oil spills	Electrical/Oil
10	Plant-Wide Components	Battery chargers	Electrical cabinets	Electrical
11	Plant-Wide Components	Cable fires caused by welding and cutting	See Appendix R of [1]	Welding
12	Plant-Wide Components	Cable run (Self-ignited cable fires)	See Appendix R of [1]	Electrical

Table 6: Recommended Severity Factors and Suppression Curves for Ignition Sources in the Frequency Model.

ID	Location	Ignition Source	Heat Release Rate (HRR) Probability Distribution for Calculation of Severity Factor	Suppression Curve
13	Plant-Wide Components	Dryers	Transients	Transients
14	Plant-Wide Components	Electric motors	Electric motors	Electrical
15	Plant-Wide Components	Electrical cabinets	Electrical cabinets	Electrical
16	Plant-Wide Components	High energy arcing faults	See Appendix M of [1]	See Appendix M of [1]
17	Plant-Wide Components	Hydrogen Tanks	See Appendix N of [1]	Flammable gas
18	Plant-Wide Components	Junction box	Electric motors	Electrical
19	Plant-Wide Components	Miscellaneous hydrogen fires	See Appendix N of [1]	Flammable gas
20	Plant-Wide Components	Off-gas/Hydrogen recombiner (BWR)	See Appendix N of [1]	Flammable gas
21	Plant-Wide Components	Pumps	Pump (Electrical)/Oil spills	Electrical/Oil
22	Plant-Wide Components	RPS MG sets	Electric motors	Electrical
23a	Plant-Wide Components	Transformers (Oil filled)	Oil spills	Oil
23b	Plant-Wide Components	Transformers (Dry)	Electric motors	Electrical
24	Plant-Wide Components	Transient fires caused by welding and cutting	Transients	Welding
25	Plant-Wide Components	Transients	Transients	Transients
26	Plant-Wide Components	Ventilation subsystems	Electric motors/Oil spills	Electrical/Oil/ Transients
27	Transformer Yard	Transformer – catastrophic	See Section 6.5.6 of [1]	Outdoor transformers
28	Transformer Yard	Transformer - noncatastrophic	See section 6.5.6 of [1]	Outdoor transformers

Table 6: Recommended Severity Factors and Suppression Curves for Ignition Sources in the Frequency Model.

ID	Location	Ignition Source	Heat Release Rate (HRR) Probability Distribution for Calculation of Severity Factor	Suppression Curve
29	Transformer Yard	Yard transformers (others)	See section 6.5.6 of [1]	Outdoor transformers
30	Turbine Building	Boiler	Oil spills	Oil
31	Turbine Building	Cable fires caused by welding and cutting	See Appendix R of [1]	Welding
32	Turbine Building	Main feedwater pumps	Pump (Electrical)/Oil spills	Electrical/Oil
33	Turbine Building	T/G exciter	Not considered for non-power POSs	
34	Turbine Building	T/G hydrogen	See Appendix O of [1]	Turbine generator
35	Turbine Building	T/G oil	See Appendix O of [1]	Turbine generator
36	Turbine Building	Transient fires caused by welding and cutting	Transients	Welding
37	Turbine Building	Transients	Transients	Transients

- If a fixed, gaseous fire suppression system is available, actuation of that system is assumed to disrupt the process of fire growth and spread sufficient to achieve effective control of the fire. However, the duration of control is assumed to be the time period over which it has been demonstrated, by test or analysis, that a sufficient suppressant concentration, per applicable standards, can be maintained.
- Core damage would occur if the MCR operators are unable to use the main control board (MCB) and no actions are taken from outside the MCR.

4.11.4 Single Compartment Fire Scenarios

The overall process for analyzing single compartment fire scenarios for LPSD fire PRA, regardless of the POS, remains the same as what is presented in reference [1] for full-power fire PRA. For LPSD fire PRA, the analyst should ensure that the following issues are addressed:

- The heat release rate (HRR) of the ignition sources and other combustibles reflect the conditions of the POS. For example, if the doors of an electrical cabinet are opened during a specific POS, the heat release rate of that cabinet should be modified to reflect the POS-specific condition.
- Status of protective barriers should be verified. For example, heat shields may be removed temporarily for maintenance work while the ignition sources remain operational.
- Status of detection and suppression systems should be verified. For example, parts of an automatic suppression system may be valved off for repair or modification work.

- If the fire brigade is credited, the path between fire brigade equipment and the PAU should be reviewed and the response time adjusted. Longer response times should be used if there is a possibility of maintenance or other activities in the PAUs along the fire brigade's path.
- Transient ignition sources should be characterized carefully to reflect the additional items that may be brought into the PAU. Under certain POS that include maintenance activity or plant modification, the quantity and type of transient materials may be different.
- Secondary combustibles should be specifically characterized in case of POS that include maintenance activities and plant upgrade. Quantity, type and position of potential combustible materials should be identified. Where in doubt, conservative assumptions should be used and carefully recorded.
- If there is a potential for erecting scaffolding or other structures to be used as a temporary platform for staging maintenance work, the analyst should postulate secondary combustibles accordingly using conservative assumptions where the specifics of the activity may not be completely defined.

4.11.5 Analysis of Fire Scenarios in the MCR

The MCR analysis methodology remains the same as in reference [1]. The conditions within the MCR, and especially the alternate shutdown system, may be markedly different under certain POS. However, the same key concerns apply to LPSD conditions. The MCB should be examined for specific areas where fire damage can lead to a significant CCDP. All other control boards and electrical cabinets should be examined for potential risk impact. Finally, the possibility and likelihood of MCR abandonment should be examined.

For LPSD fire PRA, the analyst should ensure that the following issues are addressed:

- Activities within the MCR should be characterized and changes that can impact the fire risk profile identified. For example, the number of personnel within the MCR may increase. Multiple parallel activities may be taking place. Electricians could be working inside the MCB.
- When analyzing the MCB, the analyst should understand which controls will be tagged and the position of the control device while tagged.
- The MCB fire propagation and suppression curve presented in Appendix S of reference [1] can be used for all POS cases except those that include a maintenance activity behind the main face of the board. If such an activity is planned, the specifics of those tasks should be identified and evaluated. A set of fire scenarios may need to be identified to address those specific activities. Those scenarios should cover new ignition sources introduced inside the MCB and fire growth starting with that source and propagating to secondary combustibles (i.e., vertical and horizontal wire bundles and electrical and electronic devices). The target sets should be identified carefully in terms of the circuits present in the affected wire bundles and controls on the control board. The detection and suppression curves for MCR fires may still be used for these cases.

- Operating procedures for LPSD conditions will need to be reviewed and assessed. Substantial changes to fire-related operator manual actions may occur when the plant transitions to LPSD operations.
- Both remote and alternate shutdown capabilities should be re-examined using the specific condition imposed by the POS to assess their role in, and relevance to, LPSD operations. Access to the remote/alternate shutdown location(s) could be different during LPSD. The alternate shutdown circuits could also be altered. These issues should be identified and taken into account when analyzing operator error using the alternate shutdown capability.
- MCR abandonment calculations may need to be reviewed and verified for applicability to the specific POS conditions. If the transient combustibles profile or electrical cabinet characteristics are altered, the calculations for MCR abandonment should be verified.

4.11.6 Analysis of Fire Scenarios Initiated Outside the MCR that May Impact MCR Functions or Habitability

The possibility of adversely impacting the MCR function by a fire outside the room, as in full-power fire PRA, should also be examined. As discussed in reference [1], there could be other compartments where a fire may damage sufficient control circuits rendering a part of the MCR function inoperable or affect the information displayed for the operators. Also, there could be locations where a fire may adversely impact the MCR environment forcing abandonment. It is very possible that these compartments are the same as those identified in the full-power fire PRA. However, it is recommended that the analyst revisit this task and re-examine the underlying assumptions and information. Conditions associated with a specific POS may lead to areas within the plant or fire scenarios other than those identified in the full power analysis that can adversely affect the MCR. Two specific areas of consideration should be included as follows:

- The locations that might lead to functional degradation of the MCR control and indication systems could change based on the POS and plant status. This is because the systems and indications which are most important to maintaining core integrity will change depending on the POS, which means the location of equipment and cables of potential concern could also change.
- The status of fire barrier elements (e.g., opened doors or breached barriers) could create smoke, heat, and fire spread paths that were not considered plausible in the full-power fire PRA.

4.11.7 Analysis of Fire Scenarios Impacting Multiple Compartments

Multi-compartment fire propagation and damage analysis as presented in reference [1] uses four screening steps to arrive at fire scenarios that could be risk significant and that thereby may warrant a more detailed analysis. The detailed analysis uses the same general approach as does the single-compartment fire analysis. The same screening steps can be used for LPSD conditions as those described in reference [1]; however, the conditions relevant to screening could be markedly different under certain POSs.

For LPSD fire PRA, the analyst should ensure that the following issues are addressed:

- The exposing and exposed compartment matrix should be reviewed and updated to reflect the POS-specific status of PAU partitioning elements (e.g., breached barriers or open hatches and doorways).
- Multi-compartment fire damage target sets will need to be re-defined to reflect the equipment and cables important to maintaining core integrity for each identified POS.
- Once the compartment relationships have been re-defined, the same screening assumptions and criteria can be used to identify compartment combinations that warrant more detailed analysis. However, the screening analysis should consider that fire protection features and systems that were credited in the full-power fire PRA may be unavailable or degraded under LPSD conditions. Screening should be performed accordingly.
- For barriers whose status and integrity are not changed, the failure probabilities and guidance provided in reference [1] can be used.
- If a particular barrier element will be breached during a specific POS (e.g., hatch removal or a specific outage plan that involves breaching of fire barrier elements) it is recommended that the analysis should treat the breached barrier as a non-confining partitioning element relative to the spread of fire or fire products (e.g., smoke, heat and toxic gas). The importance of breaching such barriers can be assessed in a sensitivity study if necessary.

4.12 Task 12: Post-Fire Human Reliability Analysis

4.12.1 Background

While considerable effort has been directed toward the development of human reliability analysis (HRA) methods and approaches, historically, most of these efforts have resulted in methods and approaches that are intended to apply to full-power internal events PRA applications.

One exception is the recent joint development of fire HRA guidance by EPRI and NRC-RES[7] which supersedes that given in NUREG/CR-6850, EPRI TR-1011989. Consequently, it is recommended that for the purposes of LPSD fire PRA, the updated joint RES-EPRI fire HRA guidance be used, in combination with the special considerations for LPSD conditions given below. As with other elements of the LPSD fire PRA methodology, Task 12 also assumes the existence of a LPSD, internal events PRA that includes corresponding HRA elements.

It is also recommended that only the detailed HRA analysis approaches as described in the joint RES-EPRI fire HRA guidance be used. No specific development effort for LPSD Fire HRA guidance has been undertaken so it is not known how relevant the screening and scoping HRA

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[7] Publication of the final RES/EPRI fire HRA guidance remains pending. The guidance document has been released as a draft for public comment (see reference: NUREG-1921, EPRI TR-1019196) and is available at the following web address: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1921/.

approaches from the joint guidance document would be to LPSD conditions. Finally, consistent with overall fire PRA guidance and standards, the fire HRA guidance does not address pre-initiator human failure events (HFEs) (or latent human failures). Pre-initiator HFEs will need to be addressed using typical full-power, PRA approaches, supplemented by any special considerations for LPSD conditions.

At present, no specific HRA guidance has been developed for LPSD PRA, paralleling that for at-power fire HRA/PRA. However, a variety of applications of HRA for LPSD internal events PRA have been performed, including two PRAs sponsored by the NRC [7,8]. Also, preliminary development work to support a LPSD HRA method was performed in the early 1990s [9,10]. Consequently, there is some basis for performing LPDS HRA/PRA even in absence of a comprehensive LPSD-specific approach.

4.12.2 Special Considerations Related to LPSD

Since, as discussed above, no comprehensive LPSD-specific HRA method has been developed, the recommended approach, at present, is to combine some known, LPSD-specific considerations with the joint RES-EPRI guidance developed for at-power fire HRA.

The following are examples of such considerations (but should not be considered a complete list):

- Plant conditions or configurations typically are different for LPSD than for full-power (potentially resulting in function, system, equipment, instrumentation and control, as well as indication and alarm, unavailability). HRA analysts should be aware that some of these condition or configuration differences may matter only to the operators (i.e., there may be no impact on plant equipment as in the case, for example, of control room indication unavailability). For fires during LPSD, indications needed to identify the fire location may be effected. Also, the HRA analyst should collect information on how control room operators maintain an awareness of plant conditions and configurations (e.g., log books, shift turnover briefings, schematics, risk monitors).
- Success criteria for plant functions are likely to be different during LPSD conditions, changing operator actions (e.g., number of pumps that need to be started, manual action required for initial response rather than backup/recovery of automatic actuation) and changing the required timing for response.
- Different and additional human failure events should be addressed in LPSD HRA, largely because of the two preceding items. In particular:
  - The HRA may be needed to explicitly address human-induced initiating events. As noted in NRC's Good Practices Guidance [11], if there are important dependencies between operator actions that cause an initiating event and the actions required for accident response, then the human-induced initiator should be addressed explicitly.
  - Because of the increased number of maintenance, testing, and other outage activities during shutdown, the number of potential pre-initiator HFEs or latent failures also increases. The HRA analyst should review relevant information to identify such opportunities and realistically provide credit for recovery of such failures (i.e., do not credit multiple, independent verifications).

- Which procedures are used for accident mitigation, how they are used, and how they are entered can be different for LPSD than for full-power. The HRA analyst should review all of these aspects with respect to procedure usage.

- Operator training for response to LPDS accidents is likely to be different, in frequency and depth, from that for full-power. Similarly, training for LPDS fire events may be even less than that for general LPSD plant operations.

- Staffing of the control room during LPSD is likely to be different than that for full-power and should be reviewed by the HRA analyst. In addition, as in the at-power fire HRA guidance, the HRA analyst should determine if some control room staff will be required to serve roles on the fire brigade, making them unavailable for control room actions.

- There can be concerns related to staffing, procedures, and training in combination for fire HRA/PRA for both full-power and LPSD. In particular, the HRA analyst should identify situations in which the following occurs:

    - Fewer operators are in the control room for a fire event than for an internal events accident, and/or

    - multiple procedures (e.g., emergency operating procedures and fire response procedures) are being used with individual operators assigned to independently implement one of the two or more procedures (i.e., the control room operators are no longer operating as a normal crew), and

    - use of multiple procedures (especially, use of fire response procedures) is not normal operating practice and there is infrequent training on the use of multiple procedures that require coordination.

There are other considerations that can be important in performing LPSD HRA such as:

- ex-control room or local actions (with, for example, different human-machine interface issues than the control room),
- accessibility of equipment,
- environmental factors (such as habitability),
- special fitness needs, and
- needs for special equipment or tools.

These issues (and others) are explicitly addressed in the joint RES-EPRI fire HRA guidance and, therefore, are not discussed here. The same approaches for dealing with such factors as are outlined for at-power conditions are expected to apply to LPSD conditions.

4.13 Task 13: Seismic-Fire Interactions Assessment

A qualitative approach is used in reference [1] to address potential seismic-fire interaction cases using the approach recommended in the Fire Risk Scoping Study [12]. That approach identified the following four seismic-fire interaction issues:

- Seismically induced fires,

- Degradation of fire suppression systems and features,
- Spurious actuation of suppression and/or detection systems, and
- Degradation of manual firefighting effectiveness.

All four issues are applicable to plant conditions during LPSD POS(s). The main assumption about low risk of seismically induced fire events can be extrapolated to LPSD conditions. However, during LPSD conditions, many activities will occur in the plant that would not be observed, or will be undertaken in areas where they would be disallowed, during full power operation. For example, welding and cutting operations could introduce portable compressed gas cylinders in unexpected locations, transient combustible control restrictions may be relaxed, maintenance activities may introduce a range of temporary storage items in various plant locations, and operations involving temporary hoisting or rigging equipment may be undertaken. These factors would tend to indicate that the probability of a seismic-fire interaction event *given an earthquake* (i.e., an event that can be attributed to one of the four issues listed above) is expected to be higher during an LPSD condition than full-power. Nonetheless, the overall risk is deemed to remain low largely because of the short duration of LPSD conditions.

The following assumptions are made relative to the seismic-fire analysis:

- A full-power Seismic-Fire Interaction Assessment exists.
- A post-earthquake plant response analysis exists for the specific POS being considered.
- A separate, stand-alone assessment should be conducted for each postulated POS.
- The assessment should be walkdown-based and may be qualitative.

The same seven step approach applied to the full-power fire PRA can be used for LPSD. The following notes summarize the key issues of seismic-fire interaction assessment related to LPSD:

- Step 1: Identify key seismic-fire interaction analysis PAU: The PAUs that contain post-earthquake response components and circuits are identified in this step. Component and circuit conditions may be altered during LPSD conditions. Those PAUs where altered components and circuits are located should specifically be identified in this task. Similarly, those PAUs where a manual action is credited should be included in the analysis.

- Step 2: Assess potential impact of seismically induced fires: The special conditions during a POS should be taken into account to assess the potential impact of seismically induced fires. As in the full-power case, the assessment should be focused on the PAUs that were identified in Step 1. A plant walkdown and a review of potential special conditions during a POS are essential in this step.

- Step 3: Assess seismic degradation of fire suppression systems and features: The analysis conducted for full-power conditions can be reviewed and modified if any part of the fire suppression systems and features will be modified during the postulated POS.

- Step 4: Assess the potential impact of spurious fire detection signals: Spurious fire detection signal as a result of dust or steam (caused by equipment shaking or pipe break) could be more likely because of maintenance activities. The full-power analysis can be reviewed and modified to reflect the special conditions of postulated maintenance activities.

- Step 5: Assess the potential impact of spurious fire suppression system actuations: The full-power analysis can be used to establish the cases where spurious fire suppression actuations are possible. The impact of such events should be reviewed against the conditions postulated for each POS and modified accordingly.
- Step 6: Assess the potential impact of a seismic event on manual firefighting: For each compartment identified in Step 1, the manual fire fighting possibility should be reviewed in the same way as for full-power analysis by taking into account the LPSD conditions.
- Step 7: Complete documentation: Apply the same guidelines as provided for the full-power analysis.

4.14 Task 14: Fire Risk Quantification

The objectives and overall approach for risk quantification is the same as in full-power fire PRA as described in reference [1]. However, the basis of quantification may vary depending on the intended objectives and applications. In this task, the final LPSD fire PRA model is quantified to obtain the final fire risk results in terms of CDF and LERF for each fire scenario defined in Task 11. The scope of this task will depend on the scope of the LPSD analysis. If an overall or average outage analysis is the main objective, the CDF and LERF calculations should be repeated for each POS and combined according to the equations in Section 3 above. If a specific POS (or subset of POSs) is analyzed, the CDF and LERF should be estimated using the same equation, except that only one POS (or a specific group of POSs) is considered.

Similar to full-power PRA, it is expected that the nature (e.g., type of sequences) of the screened out compartments/scenarios is at least identified. As a check of the cumulative screening criteria discussed in Task 7, it is recommended that the screened CDFs and LERFs also be summed separately to provide a perspective on the total residual risk from the screened compartments/scenarios. It should be emphasized that these screened portions of the results represent various levels of analysis (for instance, some may only involve fire scoping modeling; others may involve both detailed fire modeling and some detailed circuit analysis, etc.).

This task uses the LPSD fire PRA Model to quantify CDF and LERF. The model is initially developed in Task 5 (Fire Induced Risk Model), and modified in the quantitative screening performed in Task 7. This task also requires input from Task 10 (Circuit Failure Mode Likelihood Analysis), Task 11 (Detailed Fire Modeling), and Task 12 (Post-Fire Human Reliability Analysis).

The fire PRA analysts will need basic event occurrence probabilities from the Internal Events LPSD PRA Model to be able to quantify accident sequence frequencies where the fire scenario does not affect all basic events of the sequence. Also, the analyst should have access to the software tools required to quantify the PRA Model.

As noted above, the procedure in this task is the same as the RES/EPRI full-power fire PRA methodology. With the exception of fire-specific elements of the quantification process, this procedure relies heavily on the approach provided in the ASME/ANS PRA Standard [13]. The LPSD fire PRA Model developed in previous tasks is used to quantify CDFs and LERFs for each fire ignition event.

4.15 Task 15: Uncertainty and Sensitivity Analyses

This procedure provides an overall approach to all the other tasks on suggested ways to address the uncertainties associated with each task in the LPSD fire PRA process. In addition to uncertainty analysis, the identification of possible sensitivity analysis cases is addressed in this procedure. The discussions provided in Chapter 15 of reference [1] on uncertainty and sensitivity analyses and the guidance provided in reference [1] apply to LPSD cases as well. This task describes the approach for identifying and treating uncertainties and identifying sensitivity analysis cases. It also prescribes a review for the identified uncertainties among the fire PRA analysts to establish an integrated approach for addressing the effects of these uncertainties on the final results.

Many of the inputs that make up the LPSD CDF and LERF estimates, as in full-power fire PRA, are uncertain (e.g., fire frequencies, extent of fire growth, equipment failure probabilities, operator action probabilities, etc.). Additionally, there may be uncertainty in the fraction of the time that the plant could be in a specific POS. See Section 3 above for a brief discussion on the use of these fractions. Uncertainties in the input parameters lead to epistemic uncertainties in the LPSD Fire CDF and LERF. The same methods as for full-power fire PRA can be used to estimate the uncertainty distributions for the LPSD PRA analysis.

Similar to full-power fire PRA, it is important that users of the results of the LPSD fire PRA understand the fundamental modeling assumptions underlying the analysis and the sources of uncertainty associated with the results. Some uncertainties may be specifically included in the quantification of the results; others may only be qualitatively addressed or not addressed at all.

The analysts for Tasks 1 through 13 are expected to follow the overall approach provided in this procedure to articulate and quantify, when necessary, the uncertainties in their numerical results. For each affected task, the following information will be needed for uncertainty analysis:

- Sources of uncertainties, and
- Proposed approach for addressing each of the identified uncertainties.

It is expected that specific parameters and assumptions for which uncertainty or sensitivity analyses can provide valuable insights on the LPSD Fire CDF and LERF will be identified during the performance of an LPSD fire PRA. To that extent, the issues addressed here should be modified to reflect the key uncertainties identified on a plant-specific basis.

The same procedure as that described in reference [1] for full-power fire PRA applies here as well.

- Step 1: Identify Uncertainties Associated with Each Task: Where applicable, the outcome of each preceding task should include a discussion on the uncertainties in the results of the task. That information is collected and reviewed in this step. The uncertainties in the fraction of the time that the plant could be in a specific POS should also be addressed in this step. A determination should be made about the extent of those uncertainties and including them in the uncertainty analysis process.

- Step 2: Develop Strategies for Addressing the Uncertainties: Analysis strategies developed for the full-power fire PRA or LPSD internal events PRA could be applicable to LPSD conditions as well. Those strategies may be reviewed and adopted as appropriate.

- Step 3: Perform Review of Uncertainties to Make Final Decisions as to Which Uncertainties Will Be Addressed and How: A review of the parameters to identify those that will be included in the uncertainty analysis is conducted in this step. Another important result of this step is a set of sensitivity analysis cases.
- Step 4: Perform the Uncertainty and Sensitivity Analyses: Uncertainties are propagated through the model and sensitivity cases are performed. The same methods as in the full-power fire PRA or LPSD internal events PRA can be used to propagate the uncertainties. Sensitivity analyses may require their own unique approach depending on the sensitivity case, but should not be different from the methods used for full-power fire or LPSD internal events cases.
- Step 5: Include the Results of the Uncertainty and Sensitivity Analyses in the fire PRA Documentation: The same documentation approach can be used as in full-power case.

4.16 Task 16: Fire PRA Documentation

The objective of this task is to ensure there is adequate documentation of the fire PRA to allow review of the PRA development and its results, as well as to provide a written basis for any future uses of that PRA. The recommended documentation in reference [1] applies to LPSD fire PRA as well. A recommended outline of the report and a list of supporting documents are provided in Tables 16-1 and 16-2 of reference [1]. That outline and recommended supporting documents apply to LPSD fire PRA as well. Certainly the LPSD fire PRA report should have a clear discussion of the POSs analyzed and the assumptions made to define the POSs. As noted in reference [1], the documentation should provide an adequate summary of the development of the LPSD fire PRA, including the performance and results of all the previous tasks in this document and the results of the LPSD fire PRA itself (with uncertainties, sensitivities, observations, etc.).

4.17 Task 17: Plant Walkdowns (Support Task A)

Plant walkdown is defined in reference [1] as an inspection of local areas in an NPP where systems and components are physically located to ensure accuracy of procedures and drawings, equipment location, operating status of equipment, and environmental or system interaction effects on equipment during accident conditions. As noted in reference [1] and for LPSD conditions, paper and electronic documents are not sufficient to provide all the information needed for a proper fire PRA. Therefore, plant walkdowns are critically important when conducting an LPSD fire PRA.

The guidance provided in reference [1] applies to LPSD conditions as well. The walkdowns already conducted in support of full-power fire PRA should provide the baseline information that will be modified according to the special conditions imposed by the LPSD POS. It is anticipated that a separate set of walkdowns will be necessary in support of each POS. The pattern of the walkdowns (i.e., those defined in Table 17-1 of reference [1]) is expected to remain the same. However, not all walkdown types may be necessary. In addition to the guidance provided in Chapter 17 of reference [1], the following notes are provided for LPSD fire PRA related walkdowns:

- A separate set of walkdowns and especially walkdown notes should be created for each POS.

- As part of the initial walkdown, a separate meeting with plant management should be requested. In this meeting the specific conditions of the POS being studied should be reviewed and verified.
- Engineering documents (e.g., plant layout drawings) may need to be taken to the plant and marked up to reflect the anticipated changes during a specific POS.
- An effort should be made to discuss anticipated POS related transient combustibles and hot work with plant personnel to establish the changes to the extent possible.
- Plant areas where changes may take place should be visited and the walkdown notes updated or new ones created for the affected compartments.
- A walkdown may be planned during the plant shutdown to confirm the information that was gathered prior to the shutdown. This walkdown may take place after LPSD fire PRA is completed. If marked differences are noted, management should be notified to make a determination about updating the PRA.

4.18 Task 18: Fire PRA Database System (Support Task B)

The fire PRA Database System is a relational database of equipment, circuits and plant locations. It may also include cable raceway information and equipment failure modes. The main purpose of the database is to assist in fire scenario development, establishing the target set of each scenario and equipment failure modes given fire damage. The database developed for full-power fire PRA can be used in LPSD fire PRA as a starting point. The same assumptions apply to LPSD. Tasks 2 and 3 related information should be reviewed to identify components, circuits and cables other than those included in the full-power PRA. The database should be updated to include the new information. All other features of the database remain the same as those discussed in reference [1].

5 References

[1] EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities, a joint publication of the U.S. NRC and EPRI, NUREG/CR-6850, EPRI TR #1011989, Volume 2, September 2005.

[2] NFPA Standard 805, Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants, 2001 Edition.

[3] *Code of Federal Regulations*: Section 10CFR50.48, "Fire Protection," subsection (c), "National Fire Protection Association Standard NFPA 805."

[4] "American National Standard, Low Power and Shutdown PRA Methodology", ANSI/ANS-58.22-200x, DRAFT #8C, for RISC Reba lot & Public Review, June 2008.

[5] NUREG-1921/EPRI 1019196, "EPRI/NRC-RES Fire Human Reliability Analysis Guidelines," Draft Document for Public Comment, U.S. Nuclear Regulatory Commission, Washington, DC, July 2009.

[6] Kaplan, "On a 'Two-Stage' Bayesian Procedure for Determining Failure Rates from Experiential Data," *IEEE Transactions on Power Apparatus and Systems*, Volume PAS-102, 1983, pp. 195-202.

[7] An Approach for Using Probabilistic Risk Assessment In Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis, U.S. NRC, Regulatory Guide 1.174, Revision 1, November 2002.

[8] "Wolf Creek Incident Investigation Team Report," 94-04, Revision 2, U.S. Nuclear Regulatory Commission, April 15, 1995.

[9] NUREG-1624, "Technical Basis and Implementation Guidelines for A Technique for Human Event Analysis (ATHEANA)," Rev. 1, U.S. Nuclear Regulatory Commission, Washington, DC, May 2000.

[10] NUREG-1880, "ATHEANA User's Guide," U.S. Nuclear Regulatory Commission, Washington, DC, May 2007.

[11] Fire Risk Scoping Study: Investigation of Nuclear Power Plant Fire Risk, Including Previously Unaddressed Issues, USNRC, NUREG/CR-5088, January 1989.

[12] Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications, ASME/ANS RA-S-2008, and Addenda, ASME/ANS RA-Sa-2009.

A: APPENDIX FOR DETERMINATION OF LPSD GENERIC FIRE FREQUENCIES

A generic set of fire frequency distributions were developed to support full-power Fire PRA (see Table 6-1 of reference A-1). Those frequencies were based on EPRI Fire Events Database (FEDB) ending at January 1, 2000. A part of those frequencies that cover all operating states (i.e., full-power and shutdown phases) can be directly used in LPSD Fire PRA. These are bins in Table 6-1 of reference A-1 that are noted with "All" under the Mode column. The frequencies for the bins that are noted with "Power" had to be estimated for LPSD conditions. This Appendix is intended to describe the fire event data analysis and methodology used to estimate the fire frequencies to be applied in the LPSD Fire PRA.

A.1 Screening Events for Inclusion in the Calculation of Generic Fire Frequencies

There are 1,405 event records in FEDB that had been reviewed as part of the full-power frequency analysis for reference A-1. Events contained in the FEDB were screened for inclusion into (or exclusion from) the fire event frequency calculation based on two general considerations. The first consideration is when and where the fire occurred. The second consideration is whether or not a given event either did or could have become a potentially challenging fire (see the definition below).

A.1.1 Where and When a Fire Occurred

The FEDB was filtered to include only those events that were not assigned in the original study (i.e., the study supporting reference A-1) to "power" mode bins. Table A-1 provides the list of bins that were considered for LPSD specific fire frequency evaluation. Of the 1,405 events, 431[8] event records were assigned to a bin that needed an LPSD specific frequency analysis. The following notes are in order:

- Bin assignment was reviewed and one additional bin had to be defined to capture events in BWR containments. During power operation, BWR containments are inerted precluding the possibility of a fire event in that POS. Since BWR and PWR containments are quite different, a new bin is defined specifically for transient and hot-work fires in BWR containments (bin 3B) and the PWR containment transient and hot-work fire bin has been renamed (bin 3P rather than simply bin 3 as in the full-power set in reference A-1).
- Similar to the full-power case, although there were fire events associated with gas turbine-driven emergency generators, they are not included in this analysis because the number of emergency generators in nuclear power plants using gas turbines is not known.

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[8] One of the 431 events involved a gas-turbine based emergency generator. That event was not included in the frequency analyses.

A.1.2 Potentially Challenging Events

The second stage of event screening considered whether or not a particular event did, or had the potential to become challenging. The intent of this step is to identify reported events involving an incipient fire, fire ignition event, or explosion event that had the potential to develop into a self-sustaining fire. Events that lack this potential were screened out from the fire frequency calculation as “not-challenging”. A detailed discussion of the screening process can be found in Appendix C of reference A-1. Although the FEDB events associated with the bins in Table A-1 were already screened for challenging fire, the entire set was reviewed anew to verify the original assignments. Since this screening process is one of the important steps of data analysis, the criteria are repeated below.

Table A-1: Bins Considered for LPSD Data Analysis.

Bin #	**Location**	**Ignition Source** (Equipment Type)
2	Containment (PWR)	Reactor Coolant Pump
3B	Containment (BWR)	Transients and Hotwork
3P	Containment (PWR)	Transients and Hotwork
5	Control/Aux/Reactor Building	Cable fires caused by welding and cutting
6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting
7	Control/Aux/Reactor Building	Transients
11	Plant-Wide Components	Cable fires caused by welding and cutting
20	Plant-Wide Components	Off-gas/Hydrogen Recombiner (BWR)
22	Plant-Wide Components	RPS MG Sets
24	Plant-Wide Components	Transient fires caused by welding and cutting
25	Plant-Wide Components	Transients
27	Transformer Yard	Transformer – Catastrophic
28	Transformer Yard	Transformer - Non Catastrophic
29	Transformer Yard	Yard transformers (Others)
31	Turbine Building	Cable fires caused by welding and cutting
32	Turbine Building	Main Feedwater Pumps
34	Turbine Building	Turbine Generator Hydrogen
35	Turbine Building	Turbine Generator Oil
36	Turbine Building	Transient fires caused by welding and cutting
37	Turbine Building	Transients

The criteria for identifying potentially challenging events include objective and subjective elements. The objective criteria are based on reportable facts related to the means of fire suppression, the extent of fire growth and/or damage, fire duration, and other indicators. The objective criteria are applied in a mechanical manner–i.e., yes/no checkboxes. The subjective criteria involve the application of judgment. Factual information related to the objective criteria is often lacking in the event reports. Hence, the analysts had to use judgment to determine whether or not the event was potentially challenging, typically based on a review of the descriptive text provided for the event.

Per the objective classification criteria, a fire event was classified as potentially challenging if any one of the following is true.

- A hose stream, multiple portable fire extinguishers, and/or a fixed fire suppression system (either manually or automatically actuated) were used to suppress the fire.
- One or more components outside the boundaries of the fire ignition source were affected where the term “outside the boundaries of the fire ignition source” will depend to some degree on the specific ignition source (see further discussions below).
- Combustible materials outside the boundaries of the fire ignition source were ignited (with a similar use of the term “outside the fire ignition source” implied).

A fire event was also classified as potentially challenging if two or more of the following features are cited in an event report:

- Actuation of an automatic detection system,
- A plant trip was experienced,
- A reported loss of greater than $5,000 (not including any lost business damages), or
- A burning duration or suppression time of 10 minutes or longer.

After the objective criteria are applied, a fire event may still be classified as potentially challenging if there are sufficient indications to determine that the fire was self-sustaining or that it might have affected components or ignited materials outside the fire ignition source. This subjective method may be based on the general tone of the event report or on the observation of specific aspects of a fire event. In general, observations of the following features in an event report can be indicative of a potentially challenging fire.

- It is apparent that active intervention was needed to prevent potential spread.
- There are indications that the heat that was generated had sufficient intensity and duration to affect components outside the fire ignition source, had such been in close proximity to the ignition source.
- There are indications that flames or heat were generated of sufficient intensity and duration to cause the ignition of secondary combustibles outside the fire ignition source, had such been in close proximity to the ignition source.
- Substantial smoke was generated (e.g., a room was reported to be smoke-filled when first responders arrived on the scene, or the report includes a description such as “heavy” or “dense” smoke).

The original "potentially challenging" or "not-challenging" assignments were reviewed for each event identified as occurring during plant low power or shutdown conditions, and the assignment was modified where deemed necessary. The assignments for events occurring during power operations were left as per the original NUREG/CR-6850 assessment (they were not revised).

A.1.3 Plant Operating Mode

Each event was also examined for the plant operating mode. Most event descriptions had a clear statement about the operating mode. Since the database was filtered excluding "power" operating mode, all the events that were analyzed either clearly stated that the plant (or one of the units) was in LPSD mode or no information was provided. In the latter cases, the operating mode was assigned as "undetermined". In one case, the POS assignment of the event was modified from "low power/shutdown" to "full-power". In another case, the event had occurred during the de-commissioning phase of the plant.

A.2 Event Counting Method

To estimate the fire occurrence frequency for each bin, the total number of events associated with the bin and years of plant experience are needed. The calculation method described in Section C.4 of reference A-1 applies in the case of LPSD frequency calculations. That is, the following equation is applicable to LPSD fire frequency computations (see Section C.4.1 of reference A-1 for a description):

$$F_{plant,i} = K_i + C_i \cdot q + B_i \cdot p + BC_i \cdot p \cdot q + A_i/N + (AC_i/N) \cdot q + (AB_i/N) \cdot p + (ABC_i/N) \cdot p \cdot q$$

All the parameters of this equation have the same definition as for the full-power case with the exception of "p". The parameter "p" in the case of LPSD is the fraction of the events of known operating mode that had occurred during LPSD. In effect $p_{LPSD} = 1 - p_{full\text{-}power}$.

Note that there was no attempt made to further classify the events that occurred during LPSD based on the specific LPSD POS of the plant when these events occurred. That is, there is an implicit assumption that each LPSD event applied, for ignition frequency purposes, equally throughout LPSD (i.e., equally to all potential POSs).

A.3 Uncertainty Analysis

Uncertainty distributions of bin frequencies were established using the non-homogeneous Bayesian analysis method option of the R-DAT computer program (reference A-2). Similar to the two-stage Bayesian approach, fire event statistics of each plant are entered into the uncertainty estimation process separately to allow plant-to-plant variability influencing the uncertainty distributions. The results of this process are shown in Table A-3 in terms of the mean, 5th, 50th and 95th percentiles of the each distribution. The mean values can be used as point estimates for each ignition frequency bin.

A.4 Event Counts and Generic Frequencies

As noted above, the 431 events were reviewed and screened for challenging category and operating mode assignment. For a large number of cases, the challenging category was modified from the original study (i.e., reference A-1). Also, several of these events were concluded to be not applicable to LPSD Fire PRA. In a few cases the bin assignment had to be modified. Seven events were removed from analysis. Table A-2 provides the number of events by bins, power level (i.e., LPSD or not) and “challenging” assignment.

The total number of events that should be used for frequency calculation was estimated using the equation presented in Section A.2 above using 0.5 for q and p parameters. The results are presented in Table A-3. The corresponding total number of plant years is also presented in Table A-3 for each bin. The number of reactor years for LPSD operating mode is calculated in exactly the same way as that described in reference A-1 for the full-power operating mode.

The frequencies presented in Table A-3 are simple division of the number of fire events and the number of plant years noted.

A.5 Fire Type Split Fraction

As it is discussed in reference A-1, different fire types can be postulated for most of the ignition sources. For example, the bin “Containment (PWR) / Reactor Coolant Pumps” can refer to both electric and oil fires. The same six fire types, postulated in reference [1], are used here. Table A-4 provides the split fraction for each fire type for the LPSD specific bins. The split fractions are based on interpretations of the FEDB events.

A.6 Fire Event Classification

As it is discussed above, EPRI’s FEDB events, filtered for non full-power operating mode, were reviewed to verify the appropriate ignition source bin, the status relative to potentially challenging determination, and the operating mode assignments. For a large number of cases, the challenging category was modified. Also, a few events were concluded to be not applicable to LPSD Fire PRA. In a few cases the bin assignment had to be modified. Table A-5 provides a complete list of the events that were reviewed. Corresponding bin assignment, operating mode and challenging category are also shown. Notes are provided to indicate changes in event assessment (e.g., if “challenging” assignment was altered from the original study). Also, it is noted if the event is not included in the frequency estimation.

A.7 References

A-1 “Fire PRA Methodology for Nuclear Power Facilities; Volume 2: Detailed Methodology”, U.S. NRC and EPRI. NUREG/CR-6850 and EPRI 1011989, September 2005.

A-2 “R-DAT and R-DAT Plus 1.5 User’s Manual”, Prediction Technologies, College Park, MD, 2002.

Table A-2: Event Counts by Bin, Challenging Category and Operating Mode.

Bin #	Location	Ignition Source	Power Level	Not Challenging	Potentially Challenging	Undetermined
2	Containment (PWR)	Reactor Coolant Pump	LPSD	1	3	1
			Undetermined	1	0	0
3P	Containment (PWR)	Transient fires caused by welding and cutting	LPSD	32	10	11
			Undetermined	7	2	0
3B	Containment (BWR)	Transient fires caused by welding and cutting	LPSD	45	10	11
			Undetermined	1	0	0
5	Control/Aux/Reactor Building	Cable fires caused by welding and cutting	LPSD	0	0	0
			Undetermined	0	0	1
6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	LPSD	32	4	5
			Undetermined	17	0	2
7	Control/Aux/Reactor Building	Transients	LPSD	8	1	2
			Undetermined	4	2	2
11	Plant-Wide Components	Cable fires caused by welding and cutting	LPSD	0	0	0
			Undetermined	0	0	1
20	Plant-Wide Components	Off-gas/Hydrogen Recombiner (BWR)	LPSD	0	3	0
			Undetermined	0	0	0
22	Plant-Wide Components	RPS MG sets	LPSD	5	1	4
			Undetermined	0	0	1
24	Plant-Wide Components	Transient fires caused by welding and cutting	LPSD	9	6	3
			Undetermined	12	1	0
25	Plant-Wide Components	Transients	LPSD	11	1	1
			Undetermined	12	1	7
27	Transformer Yard	Transformer – Catastrophic	LPSD	0	5	0
			Undetermined	0	0	0
28	Transformer Yard	Transformer - Non Catastrophic	LPSD	1	1	4
			Undetermined	1	0	0
29	Transformer Yard	Cable fires caused by welding and cutting	LPSD	1	1	0
			Undetermined	0	0	0
32	Turbine Building	Main feedwater pumps	LPSD	0	1	0
			Undetermined	0	0	1
34	Turbine Building	T/G Hydrogen	LPSD	0	2	0
			Undetermined	0	0	0

Table A-2: Event Counts by Bin, Challenging Category and Operating Mode.

Bin #	Location	Ignition Source	Power Level	Not Challenging	Potentially Challenging	Undetermined
35	Turbine Building	T/G Oil	LPSD	2	1	0
			Undetermined	0	0	0
36	Turbine Building	Transient fires caused by welding and cutting	LPSD	38	8	8
			Undetermined	17	1	4
37	Turbine Building	Transients	LPSD	11	3	4
			Undetermined	8	2	3
			Totals	278	70(1)	76

(1) One fire event that was deemed as potentially challenging involved a gas-turbine. The event is not shown in this table.

Table A-3: Generic Fire Ignition Frequency Model for U.S. Nuclear Power Plants.

Bin #	Location	Ignition Source	# of Events	Total Reactor Years	Frequency (R-DAT Results)			
					Mean	5th	50th	95th
2	Containment (PWR)	Reactor Coolant Pump	3.5	519.9(1)	6.6E-03	2.6E-04	3.3E-03	1.8E-02
3P	Containment (PWR)	Transients and Hotwork	16.5	519.9	3.1E-02	2.9E-03	2.1E-02	8.2E-02
3B	Containment (BWR)	Transients and Hotwork	15.5	298.5(2)	3.5E-02	2.3E-04	7.3E-03	1.2E-01
5	Control/Auxiliary/Reactor Building	Cable fires caused by welding and cutting	0.25	822.5(3)	1.2E-03	2.3E-05	3.8E-04	3.5E-03
6	Control/Auxiliary/Reactor Building	Transient fires caused by welding and cutting	7	822.5	9.3E-03	3.6E-04	5.0E-03	2.5E-02
7	Control/Auxiliary/Reactor Building	Transients	3.5	822.5	4.7E-03	2.0E-04	2.5E-03	1.3E-02
11	Plant-Wide Components	Cable fires caused by welding and cutting	0.25	822.5	8.8E-04	1.8E-05	2.9E-04	2.8E-03
20	Plant-Wide Components	Off-gas/Hydrogen recombiner (BWR)	3	298.5	2.0E-02	8.5E-05	3.1E-03	3.8E-02
22	Plant-Wide Components	RPS MG sets	3.25	822.5	3.2E-03	1.5E-04	1.7E-03	9.0E-03
24	Plant-Wide Components	Transient fires caused by welding and cutting	8	822.5	1.1E-02	4.0E-04	5.8E-03	3.0E-02
25	Plant-Wide Components	Transients	3.75	822.5	5.8E-03	2.1E-04	2.9E-03	1.5E-02
27	Transformer Yard	Transformer - catastrophic	5	822.5	7.2E-03	8.9E-05	2.3E-03	2.1E-02
28	Transformer Yard	Transformer - noncatastrophic	3	822.5	3.8E-03	1.6E-04	1.9E-03	1.1E-02
29	Transformer Yard	Yard Transformers (others)	1	822.5	2.0E-03	2.7E-05	6.1E-04	5.7E-03
31	Turbine Building	Cable fires caused by welding and cutting	0	822.5	1.3E-03	2.2E-05	4.0E-04	3.7E-03
32	Turbine Building	Main feedwater pumps	1.25	822.5	1.9E-03	7.6E-05	8.9E-04	5.6E-03
34	Turbine Building	T/G hydrogen	2	822.5	3.0E-03	4.8E-05	1.1E-03	8.7E-03
35	Turbine Building	T/G oil	1	822.5	2.5E-03	3.5E-05	7.5E-04	6.9E-03
36	Turbine Building	Transient fires caused by welding and cutting	13.5	822.5	2.2E-02	2.5E-04	5.5E-03	7.1E-02
37	Turbine Building	Transients	6.75	822.5	1.0E-02	2.2E-04	4.3E-03	3.0E-02

(1) Total number of years PWRs were in an LPSD POS up to December 31, 2000.

(2) Total number of years BWRs were in an LPSD POS up to December 31, 2000.

(3) Total number of years all NPPs were in an LPSD POS up to December 31, 2000.

Table A-4: Fire Type Split Fractions.

Bin #	Location	Ignition Source	Electrical	Oil	Transient	Hotwork	Hydrogen	HEAF
2	Containment (PWR)	Reactor Coolant Pump	0.25	0.75	0.00	0.00	0.00	0.00
3P	Containment (PWR)	Transients and Hotwork	0.00	0.00	0.39	0.61	0.00	0.00
3B	Containment (BWR)	Transients and Hotwork	0.05	0.00	0.24	0.71	0.00	0.00
5	Control/Auxiliary/Reactor Building	Cable fires caused by welding and cutting	0.00	0.00	0.00	1.00	0.00	0.00
6	Control/Auxiliary/Reactor Building	Transient fires caused by welding and cutting	0.00	0.00	0.09	0.91	0.00	0.00
7	Control/Auxiliary/Reactor Building	Transients	0.00	0.00	1.00	0.00	0.00	0.00
11	Plant-Wide Components	Cable fires caused by welding and cutting	0.00	0.00	0.0	1.00	0.00	0.00
20	Plant-Wide Components	Off-gas/Hydrogen recombiner (BWR)	0.33	0.00	0.33	0.00	0.33	0.00
22	Plant-Wide Components	RPS MG sets	1.00	0.00	0.00	0.00	0.00	0.00
24	Plant-Wide Components	Transient fires caused by welding and cutting	0.00	0.00	0.0	1.00	0.00	0.00
25	Plant-Wide Components	Transients	0.10	0.00	0.90	0.00	0.00	0.00
27	Transformer Yard	Transformer - catastrophic	0.70	0.30	0.00	0.00	0.00	0.00
28	Transformer Yard	Transformer - noncatastrophic	0.80	0.00	0.00	0.20	0.00	0.00
29	Transformer Yard	Yard Transformers (others)	1.00	0.00	0.00	0.00	0.00	0.00
31	Turbine Building	Cable fires caused by welding and cutting	0.00(1)	0.00	0.00	1.00	0.00	0.00
32	Turbine Building	Main feedwater pumps	0.00	1.00	0.00	0.00	0.00	0.00
34	Turbine Building	T/G hydrogen	0.25	0.00	0.00	0.00	0.75	0.00
35	Turbine Building	T/G oil	0.00	1.00	0.00	0.00	0.00	0.00
36	Turbine Building	Transient fires caused by welding and cutting	0.00	0.07	0.29	0.64	0.00	0.00
37	Turbine Building	Transients	0.00	0.04	0.96	0.00	0.00	0.00

(1) Since no events were recorded during LPSD, the split fraction of the full-power analysis (i.e., reference [1]) is used.

Table A-5: Fire Event Classification.

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
9	20	Plant-Wide Components	Off-gas/Hydrogen Recombiner (BWR)	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
11	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
16	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	This event assessment was changed
18	?	Plant-Wide Components	Gas Turbines	Low Power Operation	FALSE	TRUE	FALSE	FALSE	This event assessment was changed
25	27	Transformer Yard	Transformer - Catastrophic	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
26	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
30	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
33	20	Plant-Wide Components	Off-gas/Hydrogen Recombiner (BWR)	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
56	7	Control/Aux/Reactor Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
60	32	Turbine Building	Main feedwater pumps	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
80	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
88	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
95	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
96	2	Containment (PWR)	Reactor Coolant Pump	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
107	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
112	2	Containment (PWR)	Reactor Coolant Pump	Low Power Operation	FALSE	TRUE	FALSE	FALSE	This event assessment was changed
123	37	Turbine Building	Transients	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
148	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
149	34	Turbine Building	T/G Hydrogen	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
152	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
153	28	Transformer Yard	Transformer - Non Catastrophic	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
167	2	Containment (PWR)	Reactor Coolant Pump	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
179	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
187	25	Plant-Wide Components	Transients	Undetermined	FALSE	TRUE	FALSE	FALSE	
196	22	Plant-Wide Components	RPS MG sets	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
203	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
206	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	FALSE	The plant was decommissioned at the time of the event.
210	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
225	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
226	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
227	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
232	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
245	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
247	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
248	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
253	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
265	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
272	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
274	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
276	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
277	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
278	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
281	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
283	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
284	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
287	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
290	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
293	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
294	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
297	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
303	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
309	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
311	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
313	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
314	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
315	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
316	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
325	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
334	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
335	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
336	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
337	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
339	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
342	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
343	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
344	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
345	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
348	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
350	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
355	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
356	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
359	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
360	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event was identified as Containment (PWR), Transient Fires Caused by Cutting and Welding. It was reworded it to Transient and Hotwork.

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
362	37	Turbine Building	Transients	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
371	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
373	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
375	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
377	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
378	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
379	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
380	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
382	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
383	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
386	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
387	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
392	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
393	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
394	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
408	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
409	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
411	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
412	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
424	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
426	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
429	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
430	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
443	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
447	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
450	7	Control/Aux/Reactor Building	Transients	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
464	7	Control/Aux/Reactor Building	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	This event assessment was changed

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
466	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
470	37	Turbine Building	Transients	Undetermined	FALSE	TRUE	FALSE	FALSE	
471	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
473	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
496	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
502	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
506	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	FALSE	This event was removed from the LPSD analysis because the Mode of Operation is "Power"
517	7	Control/Aux/Reactor Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
525	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
528	20	Plant-Wide Components	Off-gas/Hydrogen Recombiner (BWR)	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
530	22	Plant-Wide Components	RPS MG sets	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
532	22	Plant-Wide Components	RPS MG sets	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
539	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
540	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
545	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
552	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
556	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
557	22	Plant-Wide Components	RPS MG sets	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
568	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
580	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
581	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
582	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
583	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
586	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
588	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
589	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
590	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
591	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
592	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
594	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
599	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
600	7	Control/Aux/Reactor Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
601	35	Turbine Building	T/G Oil	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
604	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
605	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
611	22	Plant-Wide Components	RPS MG sets	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
613	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
616	35	Turbine Building	T/G Oil	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
618	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
619	37	Turbine Building	Transients	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
630	35	Turbine Building	T/G Oil	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
635	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
638	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
639	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
640	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
641	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
643	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
647	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
648	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
682	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
686	7	Control/Aux/Reactor Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
687	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
692	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
693	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
694	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
697	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
698	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
703	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
705	7	Control/Aux/Reactor Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
712	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
713	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
717	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
718	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
719	28	Transformer Yard	Transformer - Non Catastrophic	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
720	22	Plant-Wide Components	RPS MG sets	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
722	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
724	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
730	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
738	28	Transformer Yard	Transformer - Non Catastrophic	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
740	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
751	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
754	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
761	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
772	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
773	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
779	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
782	22	Plant-Wide Components	RPS MG sets	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
788	28	Transformer yard	Transformer - Non Catastrophic	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
800	22	Plant-Wide Components	RPS MG sets	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
801	22	Plant-Wide Components	RPS MG sets	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
835	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
838	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
839	28	Transformer Yard	Transformer - Non Catastrophic	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
840	21	Plant-Wide Components	Pumps	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
845	27	Transformer Yard	Transformer - Catastrophic	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
849	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
858	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
862	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
919	29	Transformer Yard	Cable fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
941	27	Transformer Yard	Transformer - Catastrophic	Low Power Operation	FALSE	TRUE	FALSE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
963	3	Containment (PWR)	Transient and Hotwork	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
964	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
965	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
966	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
968	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
969	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
970	3	Containment (BWR)	Transient and Hotwork	Undetermined	FALSE	FALSE	TRUE	FALSE	
972	37	Turbine Building	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	
974	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
981	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
983	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
990	7	Control/Aux/Reactor Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
992	7	Control/Aux/Reactor Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
995	29	Transformer Yard	Cable fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
997	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
1004	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1007	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1009	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
1010	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
1011	37	Turbine Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
1012	37	Turbine Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
1025	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
1031	2	Containment (PWR)	Reactor Coolant Pump	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1032	27	Transformer Yard	Transformer - Catastrophic	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
1040	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
1044	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
1051	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
1054	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
1060	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
1094	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
1106	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	FALSE	FALSE	Decommissioned plant. Removed from LPDS analysis.
1109	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
1111	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1117	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1120	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1121	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1136	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1138	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1143	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1144	37	Turbine Building	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
1145	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1146	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
1149	37	Turbine Building	Transients	Undetermined	FALSE	TRUE	FALSE	FALSE	
1153	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
1154	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	FALSE	TRUE	
1157	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1158	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
1161	37	Turbine Building	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
1164	7	Control/Aux/Reactor Building	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	
1165	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1166	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1172	7	Control/Aux/Reactor Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
1177	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1180	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
1192	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
1198	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	Changed the location to Control/Rx/Aux Bldg
1199	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1202	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
1203	7	Control/Aux/Reactor Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1221	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1222	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1228	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
1229	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1230	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	TRUE	FALSE	FALSE	This event assessment was changed
1231	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1233	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
1204	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1206	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1208	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
1209	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1210	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
1214	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1216	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
1219	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1234	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	TRUE	FALSE	FALSE	This event assessment was changed
1235	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1237	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
1242	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
1243	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1247	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	
1249	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	This event assessment was changed
1252	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1272	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1273	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1275	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
1278	7	Control/Aux/Reactor Building	Transients	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
1291	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
1299	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	
1300	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1301	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
1302	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
1303	3	Containment (PWR)	Transient and Hotwork	Undetermined	FALSE	TRUE	FALSE	FALSE	This event assessment was changed
1304	3	Containment (PWR)	Transient and Hotwork	Undetermined	FALSE	TRUE	FALSE	FALSE	
1305	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1306	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1307	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1311	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1312	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1313	7	Control/Aux/Reactor Building	Transients	Undetermined	FALSE	TRUE	FALSE	FALSE	This event assessment was changed
1316	7	Control/Aux/Reactor Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1324	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1325	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	FALSE	TRUE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
1329	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1341	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
1345	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
1347	3	Containment (PWR)	Transient and Hotwork	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1352	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
1354	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1360	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
1361	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
1388	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1389	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1398	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
1401	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
1424	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
1427	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
1505	28	Transformer Yard	Transformer - Non Catastrophic	Low Power Operation	FALSE	FALSE	FALSE	FALSE	This event was moved to Bin 16 (HEAF) and was not considered for LPSD analysis.
2100	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2102	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2106	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
2108	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2110	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2111	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2113	5	Control/Aux/Reactor Building	Cable fires caused by welding and cutting	Undetermined	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
2115	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2116	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2117	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2118	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
2126	11	Plant-Wide Components	Cable fires caused by welding and cutting	Undetermined	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
2129	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2131	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2132	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
2134	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2137	28	Transformer Yard	Transformer - Non Catastrophic	Undetermined	FALSE	FALSE	TRUE	FALSE	
2138	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2143	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	FALSE	TRUE	
2145	7	Control/Aux/Reactor Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2146	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2147	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
2148	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2149	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2150	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2154	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2162	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
2166	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2169	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2173	37	Turbine Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2177	27	Transformer Yard	Transformer - Catastrophic	Low Power Operation	FALSE	TRUE	FALSE	FALSE	This event was reassigned to Bin #27.
2182	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2183	32	Turbine Building	Main feedwater pumps	Undetermined	FALSE	FALSE	FALSE	TRUE	
2184	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
2188	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2190	22	Plant-Wide Components	RPS MG sets	Undetermined	FALSE	FALSE	FALSE	TRUE	
2192	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2193	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2196	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2198	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2199	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2201	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2203	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2215	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2216	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
2220	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2223	2	Containment (PWR)	Reactor Coolant Pump	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
2232	22	Plant-Wide Components	RPS MG sets	Low Power Operation	FALSE	FALSE	FALSE	TRUE	
2238	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2241	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
2244	2	Containment (PWR)	Reactor Coolant Pump	Undetermined	FALSE	FALSE	TRUE	FALSE	
2245	37	Turbine Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
2247	37	Turbine Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
2248	3	Containment (PWR)	Transient and Hotwork	Undetermined	FALSE	FALSE	FALSE	FALSE	This event was moved to Bin 12, which is not included in LPSD PRA
2257	7	Control/Aux/Reactor Building	Transients	Undetermined	FALSE	TRUE	FALSE	FALSE	
2258	24	Plant-Wide Components	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2259	34	Turbine Building	T/G Hydrogen	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
2260	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2270	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
2271	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2279	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	TRUE	FALSE	FALSE	
2286	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2291	7	Control/Aux/Reactor Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2293	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2296	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2298	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2299	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2300	37	Turbine Building	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2306	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2307	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2320	28	Transformer Yard	Transformer - Non Catastrophic	Low Power Operation	FALSE	TRUE	FALSE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
2321	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2324	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	FALSE	FALSE	"Outside the engineering office" most likely means that the location of this fire was at a place that normally gets screened out in a Fire PRA. This event was removed from the LPSD analysis.
2327	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2330	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2340	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2347	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2363	3	Containment (BWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2376	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2379	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2384	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
2385	25	Plant-Wide Components	Transients	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2398	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2403	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2414	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2415	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2421	21	Plant-Wide Components	Pumps	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2423	36	Turbine Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2444	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
2446	37	Turbine Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
2448	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
2450	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
2455	3	Containment (PWR)	Transient and Hotwork	Undetermined	FALSE	FALSE	TRUE	FALSE	
2458	37	Turbine Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
2459	3	Containment (PWR)	Transient and Hotwork	Undetermined	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
2460	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2461	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2462	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2463	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2464	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2465	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2466	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2467	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2469	24	Plant-Wide Components	Transient fires caused by welding and cutting	Undetermined	FALSE	TRUE	FALSE	FALSE	
2470	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2472	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2473	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2477	37	Turbine Building	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
2480	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2482	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2483	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2484	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2485	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2486	36	Turbine Building	Transient fires caused by welding and cutting	Undetermined	FALSE	FALSE	TRUE	FALSE	
2488	3	Containment (PWR)	Transient and Hotwork	Undetermined	FALSE	FALSE	TRUE	FALSE	
2491	3	Containment (PWR)	Transient and Hotwork	Undetermined	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2492	25	Plant-Wide Components	Transients	Undetermined	FALSE	FALSE	TRUE	FALSE	
2493	3	Containment (PWR)	Transient and Hotwork	Undetermined	FALSE	FALSE	TRUE	FALSE	
2495	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	

Table A-5: Fire Event Classification (continued).

Incident No.	Bin #	Location	Ignition Source	Power Level	High Energy Arcing Fault	Challenging	Not-Challenging	Undetermined	Comments
2496	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2497	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	This event assessment was changed
2504	3	Containment (PWR)	Transient and Hotwork	Low Power Operation	FALSE	FALSE	TRUE	FALSE	
2505	7	Control/Aux/Reactor Building	Transients	Low Power Operation	FALSE	FALSE	FALSE	TRUE	This event assessment was changed
2511	6	Control/Aux/Reactor Building	Transient fires caused by welding and cutting	Low Power Operation	FALSE	FALSE	TRUE	FALSE	

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10. SUPPLEMENTARY NOTES
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11. ABSTRACT *(200 words or less)*

The U.S. Nuclear Regulatory Commission (NRC) approved the risk-informed and performance-based alternative regulation 10 CFR 50.48(c) in July, 2004, which allows licensees the option of using fire protection requirements containted in the National Fire Protection Association (NFPA) Standard 805, "Performance Based Standard for Fire Protection for Light-Water Reactor Electric Generating Plants, 2001 Edition," with certain exceptions. To support licensees' use of that option, the NRC and the Electric Power Research Institute (EPRI) jointly issued NUREG/CR-6850 (EPRI 1011989) "Fire PRA Methodology for Nuclear Power Facilities," in September 2005. That report documents the state-of-the-art methods, tools, and data for conducting a fire Probabilistic Risk Assessment (PRA) in a commercial nuclear power plant (NPP) during full power operation. This document complements NUREG/CR-6850 (EPRI 1011989) by presenting a method for conducting a fire PRA in a commercial NPP during low power and shutdown conditions.

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