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U.S. Nuclear Regulatory Commission
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Salem Nuclear Generating Station Units 1 and 2
Renewed Facility Operating License Nos. DPR-70 and DPR-75
NRC Docket Nos. 50-272 and 50-311

Subject: Supplemental Information Needed for Acceptance of Requested Licensing Action Re: Containment Fan Cooler Unit (CFCU) Allowed Outage Time (AOT) Extension (CAC Nos. MF9364 and MF9365)

References

1. PSEG letter to NRC, "License Amendment Request: Salem Containment Fan Cooler Unit (CFCU) Allowed Outage Time (AOT) Extension," dated March 06, 2017 (ADAMS Accession No. ML17065A241)

2. NRC letter to PSEG, "Salem Nuclear Generating Station, Unit Nos. 1 and 2 - Supplemental Information Needed for Acceptance of Requested Licensing Action Re: Containment Fan Cooler Unit Allowed Outage Time Extension (CAC Nos. MF9364 and MF9365)," dated April 24, 2017 (ADAMS Accession No. ML17102A865)

In the Reference 1 letter, PSEG Nuclear LLC (PSEG) submitted a license amendment request for Salem Nuclear Generating Station (Salem), Unit Nos. 1 and 2. The proposed amendment would revise Technical Specification (TS) 3/4.6.2.3, "Containment Cooling System," to extend the allowed outage time (AOT) for one or two containment fan cooler units at Salem Nuclear Generating Station (Salem), Unit Nos. 1 and 2 from 7 days to 14 days.

In the Reference 2 letter, the U.S. Nuclear Regulatory Commission staff requested that PSEG supplement the application with information necessary to enable the NRC staff to begin its detailed technical review. A conference call was held with the NRC on April 18, 2017, to clarify the supplemental information request. The requested information is provided in the Attachment and Enclosure to this letter.

PSEG has determined that the information provided in this submittal does not alter the conclusions reached in the 10 CFR 50.92 no significant hazards determination previously

submitted. In addition, the information provided in this submittal does not affect the bases for concluding that neither an environmental impact statement nor an environmental assessment needs to be prepared in connection with the proposed amendment.

There are no regulatory commitments contained in this letter.

If you have any questions or require additional information, please contact Lee Marabella at (856) 339-1208.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 5/4/17
(Date)

Respectfully,

Charles V. McFeaters
Site Vice President
Salem Generating Station

Attachment Supplemental Information Needed for Acceptance of Requested Licensing Action Re: Amendment Request Regarding Salem Containment Fan Cooler Unit Allowed Outage Time Extension

Enclosure SA-LAR-010, "Salem CFCU AOT Extension LAR Supplemental Response"

cc: Mr. D. Dorman, Administrator, Region I, NRC
Mr. R. Ennis, Project Manager, NRC
NRC Senior Resident Inspector, Salem
Mr. P. Mulligan, Chief, NJBNE
Mr. L. Marabella, Corporate Commitment Tracking Coordinator
Mr. T. Cachaza, Salem Commitment Tracking Coordinator

Attachment

Supplemental Information Needed for Acceptance of Requested Licensing Action
Re: Amendment Request Regarding Salem Containment Fan Cooler Unit
Allowed Outage Time Extension

Supplemental Information Needed for Acceptance of Requested Licensing Action
Re: Amendment Request Regarding Salem Containment Fan Cooler Unit
Allowed Outage Time Extension

By letter dated March 6, 2017, PSEG Nuclear LLC (PSEG) submitted a license amendment request to revise Technical Specification (TS) 3.6.2.3, "Containment Cooling System," to extend the allowed outage time for one or two containment fan cooler units at Salem Nuclear Generating Station (Salem), Unit Nos. 1 and 2, from 7 days to 14 days. By letter dated April 24, 2017, the U.S. Nuclear Regulatory Commission staff requested that PSEG supplement the application to address the following requested information:

1. For the risk contribution associated with internal fires, the PRA should include
    a. A quantitative evaluation (i.e., PRA) that:
        i. Meets an NRC-endorsed industry standard;
        ii. Is peer reviewed in accordance with RG 1.200; and
        iii. Includes the result of the reviews, including all open findings and observations (F&Os), and the change in risk.

    OR

    b. A sufficient qualitative evaluation of the risk contributors that:
        i. Is of sufficient scope and depth. If the IPEEE fire evaluation is used as a basis, deficiencies in the evaluation that result from using the EPRI FIVE methodology should be addressed, including using NRC-approved methods for plant partitioning, to account for multiple spurious actuations, for plant response modeling, for fire scenario selection and analysis, to account for human reliability, for fire risk quantification, and to account for uncertainty;
        ii. Includes a discussion that clearly demonstrates why the risk contributions will not affect the decision as to the acceptability of the increase in risk;
        iii. If the basis for the qualitative evaluation relies on a PRA, the PRA should meet the criteria outlined above for quantitative evaluations.

2. For the risk contribution associated with seismic events, the LAR should include:
    a. A quantitative evaluation (i.e., PRA) that:
        i. Meets an NRC-endorsed industry standard;
        ii. Is peer-reviewed in accordance with RG 1.200; and
        iii. Includes the result of the reviews, including all open findings and observations (F&Os), and the change in risk.

    OR

    b. A sufficient qualitative evaluation of the risk contributions that:
        i. Is of sufficient scope and depth. The evaluation should be performed using current state-of-knowledge where applicable, including updated site-specific seismic hazard analyses, seismic fragility assessments, and seismic systems analysis; and
        ii. Includes a discussion that clearly demonstrates why the risk contributions will not affect the decision as to the acceptability of the increase in risk.
        iii. If the basis for the qualitative evaluation relies on a PRA, the PRA should meet the criteria outlined above for quantitative evaluations.

PSEG response

The enclosure provides supplemental information requested by the NRC staff in support of a qualitative analysis of seismic and fire hazards per NRC Regulatory Guide 1.174, Section 2.3.1. The enclosure supplements the PRA analysis provided in PSEG's March 6, 2017 submittal to support extending the Technical Specifications Allowed Outage Time for Containment Fan Cooler Units (CFCUs) during extended maintenance activities.

The qualitative evaluations described in the enclosure are of sufficient scope and depth, and clearly demonstrate why the risk contributions will not affect the decision as to the acceptability of the increase in risk. The bases for the qualitative evaluations described in the enclosure rely in part on the Salem Full Power Internal Events (FPIE) PRA Model of Record which was developed and peer reviewed consistent with the ASME PRA Standard as endorsed by Regulatory Guide 1.200. The result of the FPIE PRA reviews, including the applicability of peer review findings and observations (F&Os), was provided in Section 4.1.3 and Tables 4-1 to 4-11 in Enclosure 1 to PSEG's March 6, 2017 submittal.

Enclosure

SA-LAR-010, "Salem CFCU AOT Extension LAR Supplemental Response"

RM DOCUMENT NO:	SA-LAR-010	**REV:**	0
STATION:	Salem Generating Station		
UNIT(S) AFFECTED:	Units 1 & 2		
TITLE:	Salem CFCU AOT Extension LAR Supplemental Response		

SUMMARY:

This document provides supplemental information requested by the NRC in support of a qualitative analysis of seismic and fire hazards per NRC Regulatory Guide 1.174, Section 2.3.1. In the absence of an adequate PRA model for seismic and fire hazard groups, a qualitative treatment of these hazard groups may be sufficient provided that the licensee can demonstrate that their risk contributions would not affect the decision. This qualitative analysis supplements the PRA analysis (SA-LAR-007) that was performed to support extending the Technical Specifications Allowed Outage Time (AOT) for Containment Fan Cooler Units (CFCUs) during extended maintenance activities.

Internal RM Documentation

Electronic Calculation Data Files: N/A

	Print	Sign	Date
Prepared by:	Robert J. Wolfgang	Robert J. Wolfgang	5/4/2017
Prepared by:	Donald A. Dube	Donald A. Dube	5/4/17
Prepared by:	Usama A. Farradj	[signature]	5-3-17
Reviewed by:	Craig H. Matos	Craig [signature]	105/04/17

Method of Review: [X] Detailed [ ] Alternate

This RM documentation supersedes: N/A **in its entirety.**

	Print	Sign	Date
Approved by:	Michael A. Phillips	[signature]	5/4/17

External RM Documentation

	Print	Sign	Date
Prepared by:	N/A		
Approved by:	N/A		

Do any ASSUMPTIONS / ENGINEERING JUDGMENTS require later verification?
[ ] **Yes** [X] **No** Tracked By: AT#, URE# etc.) _____

TABLE OF CONTENTS

1.0 INTRODUCTION

When an adequate PRA model does not exist to characterize the risk associated with a license amendment request (LAR), section 2.3.2 of NRC Regulatory Guide 1.177 [1] allows for the use of a qualitative analysis. In addition, section 2.3.1 of NRC Regulatory Guide 1.174 [2] allows for a qualitative treatment of risk hazards when an adequate PRA model does not exist, provided that the licensee can demonstrate that those risk contributions would not affect the decision of the LAR.

In response to the NRC's request for supplemental information regarding the extension of the Technical Specification Allowed Outage Time (AOT) for containment fan cooler units (CFCUs), this document provides a qualitative treatment of seismic and fire hazards, showing that the risk impact would not change the original conclusion found in SA-LAR-007 [3]. The proposed change is to increase the CFCU AOT from the currently specified 7 days to 14 days for one or two CFCUs (out of five for each unit) being inoperable.

The seismic evaluation is a qualitative analysis reinforced with quantitative insights based primarily on the low seismic hazard using the updated site-specific seismic hazard curve for Salem (Salem Re-Evaluated Hazard Submittal [5,13]). Additionally, the evaluation considers the high level of redundancy and diversity of the containment heat removal (CHR) function; compensatory measures that include protecting the remaining CFCUs not in maintenance and one containment spray system (CSS) pump; and low change in the annual average probability of failure of the CHR function compared to the base case using the Full Power Internal Events (FPIE) PRA Model of Record (MOR) per RG 1.200. For fire hazards, a qualitative analysis reinforced with quantitative insights was also performed that adopted an approach that made use of the SA115A PRA MOR to evaluate the risk increase given concurrent unavailability of secondary heat removal systems and CSS.

The following sections provide the details of the qualitative treatment of seismic and fire hazards, and conclude that these hazard groups would not affect the decision of the original CFCU AOT extension request.

2.0 QUALITATIVE SEISMIC HAZARDS ANALYSIS

There is no seismic PRA model consistent with the guidance in NRC Regulatory Guide 1.200 [9] for Salem. Instead, the approach to evaluate the potential seismic risk increase resulting from the allowed outage time (AOT) extension for the CFCUs is to perform a bounding analysis. This approach and results are summarized here and represent a qualitative argument that is reinforced with a high level bounding quantitative argument. The details of this analysis are described in the following sub-sections.

The bounding analysis is based on the product of:

- The frequency of exceeding the safe shutdown earthquake (SSE) peak ground acceleration (PGA) of 0.2g, and
- The annual average change in the failure probability of the containment heat removal (CHR) function due to the AOT extension on the CFCUs with two CFCUs concurrently in maintenance and compensatory measures in place.

Seismic PRAs use PGA values as the hazard curve input for seismic frequencies of exceedance at various hazard levels. Using the updated site-specific seismic hazard curve for Salem (Salem Re-Evaluated Hazard Submittal, Table A-1 [5,13]), the frequency of the SSE PGA of 0.2g is conservatively estimated at 1.64E-04/yr[1]. In the absence of a tabulated value at 0.2g in the referenced seismic hazard report, this value is based on the higher tabulated exceedance frequency at 0.15g, using the 95th percentile hazard curve. This is a bounding analysis since it uses two conservative levels of margin: 1) the frequency of the 0.15g seismic event is higher than the 0.2g SSE, and 2) the 95th percentile value is used instead of the mean.

Using the FPIE PRA Model of Record (MOR), the annual average change in the failure probability of the CHR function was conservatively estimated to be 4.66E-04.

The product of the two values is 7.6E-08/yr. It should be emphasized that the frequency derived here is a bounding value and is not equivalent to a calculated change in core damage frequency (ΔCDF) from a seismic PRA model per RG 1.200. Rather, the

[1] For seismic PRAs, the NRC established the PGA mean hazard as the preferred way to normalize the hazard (between Lawrence Livermore National Laboratory and EPRI) in Section 3.1.1.2 of NUREG-1407. PGA is the zero-period (infinite frequency) peak ground acceleration in the horizontal direction in the free field. Thus, 100 Hz is used as a surrogate for zero-period.

derivation provides a surrogate measure of risk increase in the context of the impact of the AOT extension for CFCUs.

The CHR function for the predominant FPIE scenarios provides long-term containment heat removal where failure does not lead to a large, early release. Therefore, an increase in the AOT for CFCUs has a minimal impact on LERF in the FPIE MOR, and is also expected to have minimal impact for seismic events.

The risk metrics are found to be well within Region III of the acceptance guidelines per Figures 4 and 5 of RG 1.174 [2], with substantial margin.

2.1 TECHNICAL APPROACH

Since there is no seismic PRA model per RG 1.200 for Salem, a bounding approach was used to evaluate the potential seismic risk increase resulting from the allowed outage time (AOT) extension for the CFCUs.

The bounding analysis is based on the product of the following two terms:

- The frequency of exceeding the safe shutdown earthquake (SSE) peak ground acceleration (PGA) of 0.2g [5,13], and
- The annual average change in the failure probability of the containment heat removal (CHR) function due to the AOT extension on the CFCUs with two CFCUs concurrently in maintenance with compensatory measures in place.

A key assumption is that Seismic Category I structures, systems and components (SSCs) including, but not limited to, the reactor coolant system, Auxiliary Feedwater (AFW), Class 1E electrical power including emergency diesel generators (EDGs), CFCUs, and the CSS at Salem will not seismically fail (i.e., have an insignificant failure probability) at or below the 0.2g PGA for the SSE [5,13], as they have been designed for such events per industry codes and standards. As such, the qualitative argument is made on a deterministic basis of reasonable assurance that the probability of seismically-induced core damage at acceleration levels below the SSE is insignificant. For this analysis, seismic events beyond the SSE are assumed to always require the CHR function for accident mitigation and to prevent core damage. The CHR function has minimal contribution to large early release frequency (LERF), since the CHR function is normally associated with accident sequences leading to a “late” release.

Specific steps in the evaluation are as follows:

Step 1 is to use the FPIE PRA Model of Record (MOR) to identify the initiating events that are applicable to seismic hazards, identify the success criteria for CHR, and describe the CHR function reliability insights.

Step 2 is to derive a conservative estimate for the frequency of exceeding the SSE from the updated seismic hazard curve [5,13].

Step 3 is to use the FPIE MOR to calculate the change in the CHR function failure probability resulting from the AOT extension.

Step 4 quantifies the derived frequency from Steps 2 and 3.

Step 5 evaluates qualitatively the impact on LERF.

Step 6 characterizes the risk impact of the change to the AOT due to seismic events, then compares the derived metric values to RG 1.174 acceptance guidelines per Figures 4 and 5 for CDF and LERF, respectively, and identifies available margin.

It should be emphasized that the frequency derived in Step 4 is a bounding estimate of the change in risk due to seismic hazards, and is not to be perceived as a true calculated change in core damage frequency (ΔCDF) from a seismic PRA model that meets NRC Regulatory Guide 1.200. Rather, the derivation provides a surrogate and demonstrably conservative measure of the seismic risk increase within the context of the AOT extension for CFCUs. It is deemed conservative because it inherently assumes that any seismic event beyond the SSE induces SSC failures such as failure of all steam generator (SG) cooling, resulting in the need for primary feed and bleed, but leaves the CHR-related SSCs intact. If the CFCUs or support systems seismically fail, then the CFCUs being out-of-service is moot. In this case, there is essentially no delta between the base case with average CFCU maintenance unavailabilities and the assessed configuration with two CFCUs concurrently in maintenance with compensatory measures in place. The proposed configuration change was to increase the CFCU AOT from the currently specified 7 days to 14 days for one or two CFCUs (out of five for each unit) being inoperable.

2.2 STEP 1 - DESCRIPTION OF THE CONTAINMENT HEAT REMOVAL FUNCTION

The CHR function in the Salem FPIE PRA provides containment pressure and temperature control. For this bounding analysis, failure of the CHR function, when required, was assumed to lead to core damage in the PRA model. The CHR function is comprised of the following components:

- Containment Fan Cooler Units.
- Containment Spray System pumps and valves.
- For late pressure/temperature control, the Residual Heat Removal (RHR) system pumps and associated heat exchangers and valves drawing suction from the containment sump.
- Associated support systems including AC power, DC power, service water, and component cooling water.

The events in the PRA requiring the CHR function include:

- Feed and bleed sequences in the Transient event tree as a result of the loss of SG cooling via main feedwater and AFW.
- Loss of offsite power (LOSP) event sequences given the failure of SG cooling and the need for feed and bleed.
- Steam generator tube rupture given the need for feed and bleed.
- Small loss of coolant accidents (LOCA) if reactor coolant system (RCS) depressurization is not successful. Consequential reactor coolant pump (RCP) seal LOCAs and stuck-open primary relief valves are included in this category.
- Intermediate and large LOCAs, both for early and late containment pressure/temperature control.
- Other events requiring feed and bleed cooling.

The FPIE PRA success criteria for the CHR function for late pressure/temperature control are:

- 3-of-5 CFCUs

  OR
- 1-of-2 CSS headers from 1-of-2 RHR pumps drawing from the sump through heat exchanger(s)

Therefore, the CHR function is highly redundant and diverse. Combinations of failures of five mitigating system components/trains are necessary to fail the function, e.g., three

CFCUs and two CSS pumps. For events involving LOSP, support system failures such as the EDGs will tend to be the highest contributors to the overall CHR failure probability due to less redundancy and diversity than the CHR mitigating equipment. This amendment request does not impact these support systems.

2.3 STEP 2 - FREQUENCY OF EXCEEDING THE SSE

The frequency of exceeding the SSE PGA of 0.2g is derived from Table A-1 of Reference [5,13]. Table A-1 does not include an entry for the 0.2g PGA for the SSE. Therefore, the higher tabulated frequency of exceedance for the 0.15g level was conservatively used. Additional margin is provided by conservatively using the 95th percentile hazard curve at the 0.15g level. That value is 1.64E-04/yr.

Note that this approach does not rely on seismic fragilities of SSCs or high confidence of low probability of failure (HCLPF) capacity values.

2.4 STEP 3 - CHANGE IN CONTAINMENT HEAT REMOVAL FUNCTION FAILURE PROBABILITY

The SA115A FPIE MOR [4] was used in this analysis. A fault tree gate within this PRA model was used to represent the CHR function, and was used for both the Base Case with average CFCU maintenance unavailabilities, and the case with concurrent unavailability of two CFCUs out-of-service with compensatory measures in place. A key assumption for this analysis is that there is a LOSP. This assumption is conservative because with offsite power available, there are multiple success paths to provide AC power to the CFCUs, CSS pumps, RHR pumps, and associated valves and components. With LOSP, the five CFCUs and the redundant CSS pumps and redundant RHR pumps are dependent on the EDGs and component cooling water. Overall CHR failure probability is therefore higher with a LOSP. Given the high level of redundancy and diversity of the CHR mitigating systems, the overall CHR function failure probability in the Base Case was dominated by combinations of EDG failures and unavailability due to Test and Maintenance (TM), as well as other AC power-related SSC failures.

Similar to the expression for ΔCDF used in References [3,6], the change in the annual average CHR failure probability due to the extension of the CFCU AOT for three instances

of dual CFCU unavailability per refueling cycle (18 months), ΔCHR, was evaluated using Equations 1 and 2:

$$CHR_{NEW} = CHR_{CFCU} \times \frac{42\,days}{547.5\,days} + CHR_{BASE} \times \frac{505.5\,days}{547.5\,days} \qquad \text{Eq. (1)}$$

$$\Delta CHR = CHR_{NEW} - CHR_{BASE} \qquad \text{Eq. (2)}$$

CHR_{NEW} = Average CHR failure probability over a "typical" 18 month refueling cycle given application of the CFCU AOT extension.

CHR_{BASE} = Baseline CHR failure probability with average unavailability of CFCUs consistent with the current CFCU AOT.

CHR_{CFCU} = CHR failure probability evaluated from the PRA model with concurrent unavailability of two CFCUs out-of-service and compensatory measures in place. As was done in the previous PRA evaluation for this proposed extended CFCU AOT, common cause failure events were treated using the INL common cause data base developed under the auspices of the NRC [3]. The conditional probability of failure of additional CFCUs was adjusted to account for the hypothetical case that two out of five CFCUs have suffered a failure. This was a bounding assessment, since other more likely scenarios would lead to lower conditional probabilities and risk increases.

ΔCHR = Difference between CHR failure probability with current technical specifications and the CHR failure probability for an average 18 month cycle with three instances of concurrent unavailability of two CFCUs extended to 14 days.

Quantification of the CHR gate in the PRA MOR fault tree yielded the following results:

CHR_{BASE} = 2.956E-03

CHR_{CFCU} = 9.035E-03

CHR_{NEW} = 3.422E-03

ΔCHR = 4.66E-04

For CHR_{BASE} with offsite power assumed unavailable, the top cutsets consist overwhelmingly of various combinations of EDG failures, as well as associated AC power-

related SSC failures. In contrast, for CHR_{CFCU}, dependent failures of a third CFCU given that two are out-of-service for maintenance were found in the top nine cutsets in various combinations with other random equipment or operator action failures.

In a seismic PRA per NRC Regulatory Guide 1.200 [9], basic events related to seismically-induced failures would be added to the appropriate branches of the fault tree. Cutsets involving seismically induced failures of SSCs within the CHR function would largely cancel each other out in the above expressions for Equations 1 and 2. This is especially the case under the assumption of perfectly correlated failures of identical components in similar building locations. For example, if the CFCUs or support systems seismically fail, then the CFCUs being out-of-service is moot. For this situation, there is essentially no delta between the base case with average CFCU maintenance unavailabilities and the assessed configuration with two CFCUs concurrently in maintenance and compensatory measures in place. Given the earlier discussion that the five CFCUs and the two sets of CSS pumps and RHR pumps have dependencies on three EDGs, seismically-induced failures of EDGs and associated AC power sub-systems would fail the CHR function, and those cutsets would cancel each other out in above Equations 1 and 2.

2.5 STEP 4 - QUANTIFICATION OF THE BOUNDING FREQUENCY

The calculation of the surrogate measure of the ΔCDF resulting from the CFCU AOT extension is based on the product of:

- The frequency of exceeding the safe shutdown earthquake (SSE) peak ground acceleration (PGA) of 0.2g (in actuality, conservatively rolled up to 0.15g) using the 95th percentile hazard curve, and
- The annual average change in the failure probability of the containment heat removal (CHR) function due to the AOT extension for two CFCUs concurrently in maintenance and compensatory measures in place.

This surrogate measure is given as:

$$\Delta CDF_{surr} = 1.64E\text{-}04/yr * 4.66E\text{-}04$$

$$\Delta CDF_{surr} = 7.6E\text{-}08/yr$$

This is within about a half order of magnitude of the ΔCDF calculated for the SA115A FPIE PRA MOR results [3,6].

It should be emphasized that the frequency derived here is a bounding value and is not equivalent to a calculated change in core damage frequency (ΔCDF) from a seismic PRA model per RG 1.200. Rather, the derivation provides a surrogate measure of the risk impact within the context of the AOT extension for CFCUs. It is conservative because it inherently assumes that any seismic event beyond the SSE induces SSC failures such as failure of all SG cooling, resulting in the need for feed and bleed, but leaves the CHR-related components intact. Failure of the CHR function is assumed to lead to core damage. Because of the high redundancy and diversity of CHR, the increase in CHR failure probability resulting from this AOT extension is low.

Consideration was given in this evaluation to calculating incremental conditional core damage probability (ICCDP) and incremental conditional large early release probability (ICLERP) consistent with the definitions from Regulatory Guide 1.177 [1]. Given that the above frequency quantification is at best a surrogate measure of the increase in CDF, albeit bounding, extending this analysis to some surrogate measure of ICCDP and ICLERP is inappropriate. Therefore, these values were not determined. Given the large margin for ICCDP and ICLERP for the FPIE in References [3,6], and the large margin in the calculated frequency derived above for seismic events (in comparison to RG 1.174 acceptance guidelines), there is a high level of confidence that the RG 1.177 acceptance guidelines for these metrics would be met using a RG 1.200 seismic PRA.

2.6 STEP 5 - IMPACT ON LERF

From the FPIE MOR, LERF involves containment failure occurring early in the scenario. Early releases are defined as those releases that occur within a short time following core damage, such that adequate evacuation time is not available to protect the public from prompt health effects. Releases could be considered small if scrubbing or other fission product reduction techniques are used, but if these fail or are not available, a large release occurs.

At the Salem Generating Station, LERF sequences primarily involve either a pressure or temperature induced Steam Generator Tube Rupture (SGTR), or a pre-existing containment leakage pathway. This contribution is primarily due to various transients or internal flooding scenarios at high RCS pressure. On the contrary, the CHR function for the predominant FPIE scenarios provides long-term containment heat removal whose failure does not lead to a large, early release. Therefore, an increase in the AOT for CFCUs has only a minimal impact on LERF in the FPIE MOR, and likewise, is also expected to have only a minimal impact due to seismic events.

2.7 STEP 6 - COMPARISON AGAINST RG 1.174 ACCEPTANCE GUIDELINES

As described in RG 1.174:

> *Although the assessment of the risk implications in light of the acceptance guidelines discussed in Section 2.4 of this guide requires that all plant operating modes and hazard groups be addressed, it is not always necessary to have a PRA of such scope. A qualitative treatment of the missing modes and hazard groups may be sufficient when the licensee can demonstrate that those risk contributions would not affect the decision; that is, they do not alter the results of the comparison with the acceptance guidelines in Section 2.4 of this guide…When the PRA is not full scope, it is necessary for the licensee to address the significance of the out-of-scope items. The importance of assessing the contribution of the out-of-scope portions of the PRA to the base case estimates of CDF and LERF is related to the margin between the as-calculated values and the acceptance guidelines. When the contributions from the modeled contributors are close to the guidelines, the argument that the contribution from the missing items is not significant must be convincing and in some cases may require additional PRA analyses. When the margin is significant, a qualitative argument may be sufficient. The contribution of the out-of-scope portions of the model to the change in metric may be addressed by bounding analyses, detailed analyses, or by a demonstration that the change has no impact on the unmodeled contributors to risk.*

In the LAR submittal [3], use of the FPIE PRA model demonstrated that significant margin exists for FPIE hazards. Therefore, per NRC Regulatory Guide 1.174 [2], a bounding analysis to show that the risk contribution for unmodeled hazards such as seismic is not significant is one means of demonstrating that those risk contributions would not affect the decision. For seismic events, since there is no available RG 1.200 seismic PRA

model, a conservative estimate was used for determining a surrogate base seismic CDF strictly for comparison with Figure 4 of NRC Regulatory Guide 1.174 acceptance guidelines [2]. For this purpose, the exceedance frequency for a PGA of 0.15g at the 95th percentile from Table A-1 of Reference [5,13] was used, which was 1.64E-04/yr. This was a bounding approach in contrast with the discussion that Figures 4 and 5 in NRC Regulatory Guide 1.174 [2] were based on mean values.

However, at a PGA of 0.20g, the horizontal acceleration level for the SSE, the mean exceedance frequency was estimated to be less than 3E-05/yr based on logarithmic interpolation of the values displayed in Table A-1 of Reference [5,13]. This is the value that is used as a conservative estimate of the base total CDF value for all seismic hazards for comparison purposes with Figure 4 of NRC Regulatory Guide 1.174 [2].

The metrics for comparison against the acceptance guidelines of NRC Regulatory Guides 1.174 [2] and 1.177 [1] are provided in Table 2-1.

In EPRI Technical Report 3002003116 [7], Table 3-1 describes the challenges and ramifications when conservative methods or intentionally conservative characterizations are used. Aggregation of disparate characterizations for the various hazards can lead to overstatement of the total risk. The conservative characterization of seismic risk, for example, is undertaken only because the margin is very large. As such, the seismic risk was not aggregated with the internal events risk increase estimated by the FPIE MOR.

As stated in Reference [8]:

> *The NRC staff has reviewed the seismic hazard MSA for Salem. The NRC staff confirmed that the licensee's seismic hazard MSA [mitigating strategies assessment] is consistent with the guidance in Appendix H.4.3 of NEI 12- 06, Revision 2, as endorsed by JLD-ISG-2012-01, Revision 1. Therefore, the methodology used by the licensee was appropriate to perform an assessment of the mitigation strategies that address the reevaluated seismic hazard…The NRC staff concludes that the IPEEE-based AMS [alternate mitigating strategies] evaluation demonstrates that SSCs relied upon for mitigation strategies have seismic capacity to levels higher than the GMRS [ground motion response spectrum], safe shutdown of the plant can be accomplished, and any consequences can be appropriately mitigated.*

Therefore, for seismic hazards, the approach used in the characterization of seismic risk is both reasonable and appropriate for comparison against RG 1.174 acceptance guidelines. Moreover, the seismic analysis is of sufficient scope and depth, and clearly demonstrates why the risk contribution from seismic hazards will not affect the decision as to the acceptability of the increase in overall risk. This evaluation relies on selected portions of the FPIE MOR, which was the SA115A PRA model [4], as well as the updated seismic hazard curve for the Salem Generating Station site [5,13].

Table 2-1 lists the core damage results previously reported in Reference [3] using the SA115A MOR and the bounding estimate calculated above in Section 2.5 for seismic hazards.

TABLE 2-1
RISK METRICS FOR FPIE AND SEISMIC HAZARDS

Metric	Hazard		Risk Metric Guidelines
	Full Power Internal Events (SA115A)	Seismic	
CDF (/yr)	8.38E-06	< 3E-05 (1)	N/A
ΔCDF (/yr)	3.38E-08	< 7.6E-08 (2)	Below Region III of Figure 4 [2]
$ICCDP_{CFCU}$	1.69E-08	N/A (3)	< 1E-06 [1]

Table 1 Notes:

1. Conservatively taken as the frequency of exceeding the SSE 0.2g PGA mean hazard value (interpolated) from Table A-1 of Reference [5,13]. This value does not represent the mean CDF from seismically-induced events.
2. Conservatively calculated surrogate measure of the change in risk due to seismic hazards.
3. Not determined since the calculated risk metric was not directly related to the core damage probability.

3.0 QUALITATIVE FIRE HAZARDS ANALYSIS

The Salem Generating Station Fire PRA model has not undergone peer review and is therefore not complete with respect to the guidance of NRC Regulatory Guide 1.200 [9]. The FPIE PRA MOR was used to establish a qualitative argument using high level quantitative insights of the risk increase associated with fire hazards. The method used for evaluating the fire risk impact was similar to the philosophy adopted in 10 CFR Appendix R to Part 50, in which one train of mitigating systems are available for safe shutdown of the plant based on a deterministic evaluation, performed on a fire area basis, which assumes damage to all safe shutdown systems in the area.

A review of the internal events model evaluation for this AOT extension provides guidance for performing a qualitative fire hazards analysis based on a conservative approach that makes use of the SA115A FPIE MOR and an Appendix R type of philosophy. From the initiating event distribution of the internal events delta risk shown in Figure 3-1, note that 67.6%, 5.2% and 6.0% of the CDF increase comes from %S1 (Intermediate LOCA Initiating Event), %S2 (Small LOCA Initiating Event), and %A (Large LOCA Initiating Event), respectively. Figure 3-1 was generated by taking the quantitative PRA results from the SA115A FPIE CFCU AOT extension case and subtracting the similar cutsets found in the base case. Then, the percent contribution for initiators of the remaining cutsets is displayed graphically in Figure 3-1. A review of typical industry results shows a negligible likelihood that a fire leads to %S1, %S2, or %A [12]. Thus, these scenarios can be ignored while estimating fire risk increases associated with the CFCUs out of service. Consequential small LOCAs, such as RCP seal failures and inadvertent power operated relief valve (PORV) openings, do not fall into %S2. They are initiated by various flooding and other transient scenarios and are covered within the analysis given below.

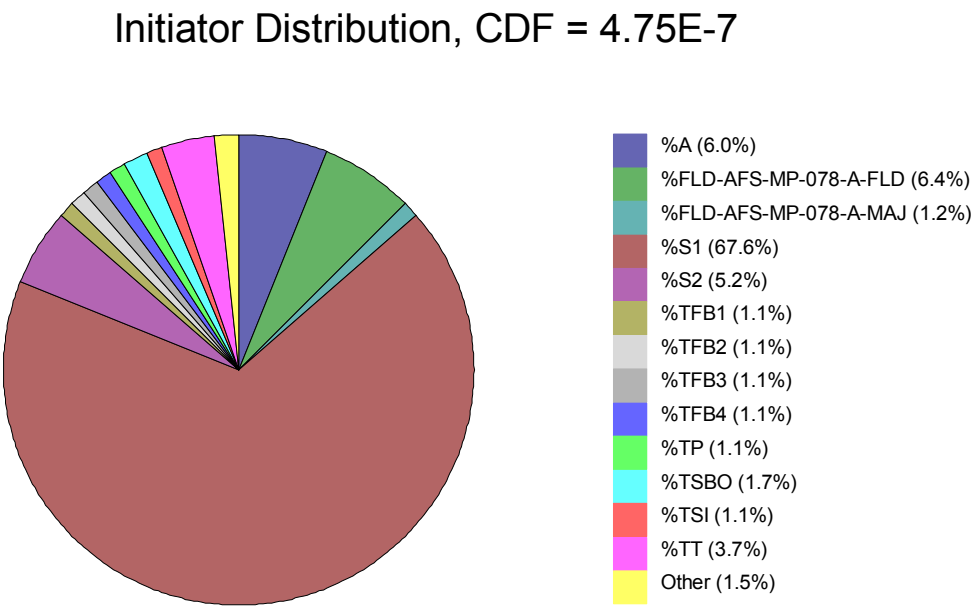

FIGURE 3-1
DELTA INTERNAL EVENTS RISK DUE TO TWO CFCUS BEING UNAVAILABLE

The next important initiating events are the 2 flooding initiating events, %FLD-AFS-MP-078-FLD and %FLD-AFS-MP-078-MAJ, which contribute about 7.6% of the risk increase (the risk increase varies slightly depending on which CFCUs are considered to be failed). The risk scenarios of interest are a flood from the Auxiliary Feedwater system in a lower level of the Auxiliary Building (AB) leading to PRA transient event tree sequence TTS24. The TTS24 internal event sequence is characterized by a trip with or without the power conversion system (PCS) available, secondary side heat removal failures that generally involve failure to implement available secondary cooling systems, and successful operation of feed and bleed heat removal using Safety Injection and PORVs. However, feed and bleed operation fails late due to the inability to recirculate water from the containment sump. The initiating events fail Service Water to an otherwise operable fan cooler and fail the MOVs necessary to operate the CSS, causing a high temperature in containment leading to possible sump recirculation failures.

Using the FPIE PRA results as a reference, specific sequences of importance relevant to the unavailability of CFCUs can be identified. The important characteristic of these sequences is failure of the steam generator cooling and containment cooling functions. The flooding sequences are the only scenarios in the FPIE that directly cause the failure of these two functions, but they contribute less than 10% of the risk increase. Since the 4th AFW pump and support systems are outside the Auxiliary Building and the CSS and its support systems are located inside the Auxiliary Building, no fire can cause the failure of both functions. Knowledge of this arrangement, along with the Salem design criteria can be used to assess the fire risk. These particular scenarios would be applicable to the potential fire events of concern.

To help reinforce the qualitative argument that fire hazards will not alter the decision to extend the CFCU AOT, a bounding analysis using quantitative estimates from the Salem FPIE PRA model was used to show the low risk impact due to the configuration involving unavailability of CFCUs. In particular, the CFCUs are mainly required in the PRA model when the CSS fails during sump recirculation. The CFCUs and CSS provide for containment heat removal during scenarios in which feed and bleed is successful when AFW is unavailable. This can be seen in the event trees for transient initiators, and also in other event trees, such as for small LOCAs, in which CFCUs are questioned when CSS fails during sump recirculation [10].

To help understand the low risk impact from fire hazards, an evaluation was performed following the intent of 10 CFR Appendix R to Part 50, in which one train of support systems are available from a deterministic standpoint. The Appendix R criteria of one train of AFW and CSS (in recirculation mode) being available can be used as the input for a worst case fire scenario. Given the systems available following a fire event, the FPIE PRA model can be used to quantify the random failures of equipment or operator actions that can lead to the loss of these systems. In combination with a fire event frequency, the quantification of the failure probability for these systems can be used as a surrogate for the fire CDF.

The following steps and assumptions were made in order to quantify a bounding ΔCDF for fire hazards using the SA115A PRA MOR:

- Combine the SA115A fault tree logic under a single AND gate and then quantify for the following systems:
  - Single train of CSS during sump recirculation.
  - Turbine-driven AFW pump, since that offers the largest unavailability for a single safety-related train of AFW.
  - Fourth AFW pump, which is located outside the Auxiliary Building in a separate location from where the safety-related AFW pumps are located.
- Conservatively use site-wide ignition frequency of 0.05/yr, which is 25% of the total site frequency value of 0.2/yr using NUREG/CR-6850 [14] (including Supplement 1 [15] and NUREG-2169 [16]). This assumes one out of four fires would lead to a plant trip, and fail all but one train of safety-related AFW, and all but one train of CSS such that the CFCUs would be required for removal of decay heat if these remaining trains also failed randomly. To show the conservative nature of this frequency, this would be equivalent to having experienced approximately 100 (i.e., 0.05/yr * ~2000 PWR rx-yr) fire-induced scenarios in the history of the PWR U.S. nuclear industry.
- The exposure time for the CFCU maintenance configuration is for three occurrences of 14 days duration per 18 month operating cycle (42/547.5).
- Assume that CFCUs are not available, i.e., system unavailability of 1.0. This provides an upper bound to the potential change in risk resulting from the CFCU AOT extension, conservatively eliminating any credit for availability of CFCUs for the duration of the fire scenario.

Table 3-1 shows that the product of the system unavailabilities multiplied by the site-wide ignition frequency and fractional exposure time results in a risk increase of 1.7E-07/yr.

TABLE 3-1
ESTIMATED DELTA RISK DUE TO FIRE HAZARDS

Concurrent Unavailability of the Following: (1) Single CSS Train in Recirculation (2) Turbine Driven AFW Pump (3) Unavailability of 4th AFW Pump	Site-Wide Fire Ignition Frequency (1/yr)	Unavailability of CFCUs	Fractional Exposure Time	Surrogate ΔCDF (1/yr)
4.56E-05	0.05	1.0	7.67E-02	1.7E-07

The above failure probabilities are associated with random failures of these systems. The 10 CFR 50, Appendix R analysis ensures that one train of AFW and one train of RHR, required to support CSS during recirculation, are available for all fire areas. Therefore, the 10 CFR 50, Appendix R analysis ensures that on a fire area basis that there are no fire scenarios where all CSS and all secondary side heat removal would both be lost. The 10 CFR 50, Appendix R analysis does not credit the 4th AFW pump. This diesel generator driven AFW pump, due to its limited support system requirements and its location will be available in addition to the 10 CFR 50, Appendix R credited AFW pump. As can be seen in Table 3-1, when all the factors are multiplied, the resultant product, which is termed a "surrogate" delta fire CDF, is less than 20% of the 1E-06/yr guideline, which falls within Region III of Figure 4 of NRC Regulatory Guide 1.174 [2].

Similar to the argument given above for seismic hazards in Section 2.7, aggregation of various hazards can lead to an overstatement of the total risk, especially when conservative and qualitative approaches are used. As such, the minimal increase in risk due to fire hazards should not be aggregated with the internal events risk increase as calculated by the FPIE MOR.

As stated above in Section 2.6, the CFCUs are concerned mainly with long-term containment heat removal where failure does not lead to a large, early release. Therefore, an increase in the AOT for CFCUs has a minimal impact on LERF in the FPIE MOR, and is also expected to have minimal impact for fire events.

Additionally, the 10 CFR Appendix R to Part 50 analysis includes the CFCUs; however, an evaluation was performed to document that in cases where no CFCUs are available, the containment temperature will remain below temperature limits for equipment inside containment [11,17]. Based on this evaluation, the unavailability of CFCUs does not impact Appendix R compliance for the Salem Generating Station.

4.0 CONCLUSION

Fire and seismic PRA models meeting NRC endorsed industry standards have not been developed for the Salem Generating Station. The fire and seismic risk contributions were instead evaluated qualitatively, reinforced with high level bounding quantitative arguments. The above sections that qualitatively evaluated the seismic and fire hazards due to extending the CFCU AOT were found not to alter the results of the comparison of the quantitative FPIE PRA calculations with the acceptance guidelines in Section 2.4 of NRC Regulatory Guide 1.174 [2]. The combination of quantitative and qualitative assessments do not affect the original conclusion documented in of SA-LAR-007 [3].

With regard to internal events, the conclusion from SA-LAR-007 [3] supported the increase in the CFCU AOT extension from a quantitative risk-informed perspective using the FPIE PRA MOR, and satisfied the NRC Regulatory Guide 1.177 [1] ICCDP and ICLERP thresholds of <1.0E-06 and <1.0E-07, respectively. Additionally, the CDF and LERF due to the CFCU AOT extension were shown to meet the risk significance guideline of Regulatory Guide 1.174 with substantial margin, i.e., Region III, which represents “very small risk changes.”

With regard to seismic hazards, the discussion found in Section 2 showed that even when a bounding approach was used to characterize the initiating event frequency for the Safe Shutdown Earthquake, the change in risk between the existing Technical Specifications CFCU AOT and the AOT extension request was found to be less than 1E-06, which is less than the NRC Regulatory Guide 1.174 [2] threshold guideline of 1E-06 for Region III. Use of a bounding quantitative approach reinforces the qualitative argument that due to a relatively low seismic hazard at the Salem Generating Station, there is no impact on the decision supporting the CFCU AOT extension.

With regard to fire hazards, the qualitative argument provided in Section 3, which made use of results from the Salem PRA FPIE MOR [4], reinforced the conclusion that there was no impact on the decision supporting the CFCU AOT extension. The margin provided by the internal events evaluation and the fact that the likelihood of fire scenarios leading to scenarios that are important to the CFCU AOT extension was less than 20% of the

NRC Regulatory Guide 1.174 [2] threshold guideline of 1E-06 for Region III. This qualitative insight was based on the fact that the unavailability of CFCUs does not have a high impact on the ability to mitigate any of the more severe fire risk scenarios, which tend to result in core damage prior to the need for containment sump recirculation and the containment heat removal function. Therefore, the available margin confirms that the contribution from fire hazards is minimal.

Neither the seismic or fire hazards risk should be aggregated since the disparate characterizations of the various hazards can lead to an overstatement of the overall risk. Also, it is not feasible to aggregate a qualitative analysis with bounding quantitative results from the FPIE PRA model.

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