

July 3, 2008

MEMORANDUM TO: Chairman Klein
Commissioner Jaczko
Commissioner Lyons
Commissioner Svinicki

FROM: R. W. Borchardt */RA/ Bruce S. Mallett for*
Executive Director for Operations

SUBJECT: REVIEW OF THE FIRE PROBABILISTIC RISK ASSESSMENTS AT
PILOT PLANTS TRANSITIONING TO NATIONAL FIRE
PROTECTION ASSOCIATION STANDARD NFPA 805,
"PERFORMANCE-BASED STANDARD FOR FIRE PROTECTION
FOR LIGHT WATER REACTOR ELECTRIC GENERATING PLANTS"

The purpose of this memorandum is to provide the Commission with a summary of the U.S. Nuclear Regulatory Commission (NRC) staff review of the Shearon Harris Nuclear Power Plant and Oconee Nuclear Station Unit 3 fire probabilistic risk assessment (PRA) models.

The Commission directed the staff to report on the reviews of the fire PRAs at the Shearon Harris Nuclear Power Plant and Oconee Nuclear Station in accordance with Staff Requirements Memorandum M080317B, "Staff Requirements – Briefing on State of NRC Technical Programs," dated April 3, 2008, Agencywide Documents Access and Management System (ADAMS) Accession No. ML080940439. These facilities are transitioning to the risk-informed, performance-based fire protection requirements pursuant to Title 10 of the *Code of Federal Regulations*, Part 50, Section 48(c) and National Fire Protection Association Standard 805 (NFPA 805), "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants."

The NRC conducted these reviews because Shearon Harris and Oconee Unit 3 are NFPA 805 pilot plants. Regulatory Guide 1.205, "Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants," establishes fire PRA industry peer review expectations for other, non-pilot licensees that intend to transition to NFPA 805.

This memorandum summarizes the findings from the NRC reviews of the fire PRA models of the two NFPA 805 pilot plants. The Shearon Harris findings are presented first, followed by the Oconee Unit 3 results.

CONTACT: Steven A. Laur, NRR/DRA
(301) 415-2889

Summary Findings from the Shearon Harris Fire PRA Staff Review

NRC staff and contractors conducted a review of the Shearon Harris fire PRA model in the first quarter of calendar year 2008. The onsite portion of the review took place the week of February 4, 2008, at the Progress Energy corporate offices in Raleigh, North Carolina.

High-Level Results of the NRC Staff Review of the Shearon Harris Fire PRA Model

The NRC review team noted that the Shearon Harris fire PRA was not yet complete – some tasks had yet to be started, and several areas were still in draft form. At the time of the onsite portion of the review, the Shearon Harris fire PRA appeared to represent a scoping analysis, rather than a completed fire PRA. Very little detailed fire modeling was completed. The screening approach to identify which areas could generate a hot gas layer appeared conservative, and the probability of spurious actuation in the model reviewed was assumed to be unity. This is significant since there were a large number of spurious actuations included in the model. The fire PRA reviewed by the NRC resulted in unrealistic risk estimates based upon analysis conservatisms.

The licensee was working to finalize the fire PRA and to reduce the excess conservatisms. For example, the licensee was conducting detailed circuit analyses so that more realistic probabilities of spurious actuation could be assigned. It appeared to the NRC review team that a large amount of work was still required to achieve a usable fire PRA model.

For these reasons, the NRC staff review of the Shearon Harris baseline fire PRA was not sufficient at that time for determination of technical adequacy to support risk-informed applications. Additional review of the completed Shearon Harris fire PRA will be necessary in the future. The NRC team recommended that the licensee consider having a full-scope industry peer review of the fire PRA model once it is complete. Since the NRC staff review, the Shearon Harris fire PRA received a focused-scope industry peer review. In the Shearon Harris license amendment request¹ to transition its fire protection program to a risk-informed, performance-based one based on the NFPA 805, the licensee states:

Following the NRC staff review, additional work was completed on the fire PRA. In April 2008, a team of industry experts in risk and fire PRA focused on those areas the NRC previously identified as not completed, had findings or were assigned a Category I quality level. ... The results of the limited peer review identified that most of the NRC identified findings were resolved and a few new findings were identified. The conclusion of the industry peer review report was that “the Harris Nuclear Plant Fire PRA substantially meets the ANSI/ANS fire PRA standard at capability category II or better. The HNP fire PRA meets capability category II or better for 87% of the applicable supporting requirements. The outstanding issues primarily pertain to completion of the final quantification and completing the documentation.” [Section 4.5.1.2]

The NRC staff has not reviewed the licensee’s statements in any detail at this point in time.

¹ Letter from R. J. Duncan, II, to USNRC, “Request for License Amendment to Adopt NFPA 805 Performance-based Standard for Fire Protection for Light Water Reactor Nuclear Generating Plants (2001 Edition),” ADAMS Accession No. ML081560639, dated May 29, 2008.

Scope of Review

The NRC staff reviewed 139 requirements² applicable to the Shearon Harris fire PRA model. An additional 18 requirements could not be reviewed because the licensee had not completed those tasks. The unreviewed areas include the elements *seismic fire* and *uncertainty and sensitivity analysis*, as well as two high level requirements in the *fire scenario selection and analysis* element. Thirty supporting requirements were not applicable for the Shearon Harris fire PRA model; for example, the licensee did not use qualitative or quantitative screening in developing the model, so the associated supporting requirements do not apply.

The scope of the NRC staff review included both estimation of core damage frequency (CDF) and large early release frequency (LERF) resulting from internal fire events. However, the licensee had not yet completed a LERF analysis.

General Findings and Results

The NRC staff reported 43 findings and 22 suggestions³ as a result of the Shearon Harris fire PRA model review. The findings and suggestions included:

- Excessive modeling conservatisms leading to unrealistic results
- Equipment selection deficiencies
- Issues with fire modeling
- Plant response model and quantification issues
- Human reliability analysis issues
- Several areas not performed (e.g., LERF analysis, uncertainty analysis, seismic-fire interaction, assessment of potential fire effect on exposed structural steel)

Approximately two-thirds of the high-level requirements had one or more supporting requirement that was not met. All applicable supporting requirements must be met in order to conclude that the high level requirement has been satisfied. As shown in the first table below, over ten percent of the applicable high-level requirements were in areas that could not be reviewed because the Shearon Harris fire PRA model was not complete at the time of the NRC staff review.

² The American Society of Mechanical Engineers (ASME) and American Nuclear Society (ANS) combined PRA Standard, ASME/ANS RA-S-2008, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Application," ("PRA Standard"), sets forth technical requirements grouped into *elements*, or constituent parts of a PRA model. *High level requirements* comprise the elements and set forth minimum requirements for meeting the PRA Standard. High level requirements are broken down into detailed *supporting requirements*; these are used to assess the technical adequacy of a given PRA model.

³ Findings and Suggestions are discussed in NEI-07-12, "Fire Probabilistic Risk Assessment (FPRA) Peer Review Process Guidelines, Draft Version F" (ADAMS Accession No. ML073551166). A *finding* is an issue or discrepancy that is necessary to address to ensure the technical adequacy of the PRA, the capability/robustness of the PRA update process, or the process for evaluating the necessary capability of the PRA technical elements to support applications. A *suggestion* is an observation considered desirable to maintain maximum flexibility for PRA applications and consistency with industry practices. Failing to resolve a suggestion should have no significant impact on the PRA results or the integrity of the PRA.

The second table shows that approximately two-thirds of the applicable supporting requirements were met. About 13 percent of the supporting requirements that were not met were in areas of the model that were mostly complete; the remaining 21 percent were in areas that were in-progress or not yet finished. However, because the Shearon Harris fire PRA was not complete at the time of the NRC staff review, major changes to the modeling and the resulting risk estimates are to be expected. Some of the changes to the model may be significant, resulting in the need for additional or follow-on review for technical adequacy, including the need to re-evaluate areas found acceptable because of changes to the model.

High Level Requirements	#	%
One or more Supporting Requirements "not met"	24	55
Not ready for review	5	11
All applicable Supporting Requirements Met	15	34
Total	44	100

Supporting Requirements	#	%
Not met – PRA model not finished	15	10
Not met – PRA model ready	21	13
Not reviewed (not complete)	18	11
Met	103	66

Summary Findings from the Oconee Unit 3 Fire PRA Staff Review

NRC staff and contractors conducted a review of the Oconee Unit 3⁴ fire PRA model in the first quarter of calendar year 2008. The onsite portion of the review took place the week of March 17, 2008, at the Oconee site in Seneca, South Carolina.

High-Level Results of the NRC Staff Review of the Oconee Unit 3 Fire PRA Model

The NRC review team noted that the Oconee Unit 3 fire PRA was not yet complete, although all tasks but one had been started. Many of the tasks had been completed. The areas requiring the most additional work included resolution of internal events PRA peer review comments, fire modeling (especially multi-compartment analysis), identification and refinement of higher risk scenarios, and completion of an uncertainty analysis. The NRC team noted that the licensee continues to work to finalize the fire PRA.

For the reasons noted above, the NRC review of the Oconee Unit 3 baseline fire PRA was insufficient for determining the technical adequacy to support risk-informed applications. The NRC team recommended that the licensee consider having a focused-scope industry peer review of those portions of the fire PRA model that change substantially in the time between the staff review and when the model is complete. In the Oconee license amendment request⁵ to transition its fire protection program to a risk-informed, performance-based one based on the

⁴ The NRC staff reviewed the Oconee Unit 3 fire PRA because it was closer to completion than the Unit 1/Unit 2 fire PRA model. The Oconee licensee plans to use the same methodology for the fire PRAs across the units. The NRC staff believes that the results of its review of the Oconee Unit 3 fire PRA should be generally applicable to the other units as well. To the extent that the licensee addresses the NRC staff's findings and suggestions consistently for all fire PRA models, the staff should be able to infer the technical adequacy of the Unit 1/Unit 2 fire PRA model based on the review of the Unit 3 model.

⁵ Letter from R. A. Jones, to USNRC, "Request for License Amendment to Adopt NFPA 805 Performance-based Standard for Fire Protection for Light Water Reactor Nuclear Generating Plants (2001 Edition)," ADAMS Accession No. ML081650507, dated May 30, 2008.

NFPA 805, the licensee did not indicate that a focused-scope industry peer review was planned. The license amendment request states:

The supporting calculations for the Unit 3 Fire PRA are awaiting approval. The open items from the Fire PRA NRC review and the internal events PRA self-assessment with potential quantification implications will be addressed within the sensitivity analysis included as part of the Change Evaluations in support of the supplement to the LAR. [Section 4.5.1]

Most of the findings from the NRC review have either been addressed or deemed to have no impact on FPRA quantification. As required, a corrective action was generated to track completion of the open item. These items either relate to documentation deficiencies or final resolution of technical issues that are not expected to have a negative impact on the FPRA (e.g., breaker coordination and demonstration of convergence for truncation limit). [Section 4.5.1.2]

The NRC staff has not reviewed the licensee's statements in any detail at this point in time.

Scope of Review

The NRC staff reviewed 172 supporting requirements applicable to the Oconee Unit 3 fire PRA model. An additional two supporting requirements could not be reviewed because the licensee had not completed the *uncertainty and sensitivity analysis* element.

The scope of this review included both estimation of CDF and LERF resulting from internal fire events.

General Findings and Results

The NRC staff reported 41 findings and 25 suggestions as a result of the Oconee Unit 3 fire PRA model review. The findings and suggestions included:

- Fire PRA model developed before resolving current PRA model issues
- Issues with fire modeling
- Plant response model and quantification issues
- Human reliability analysis issues
- Incomplete or not performed analyses (*seismic fire* element was not complete; uncertainty and sensitivity analysis not performed)

About 43 percent of the high level requirements had one or more supporting requirement that was not met. All applicable supporting requirements must be met in order to conclude that the high level requirement has been satisfied.

Almost 80 percent of the applicable supporting requirements were met. However, to the extent that substantive changes are made to complete the Oconee Unit 3 fire PRA model, additional or follow-on peer review of those changes may be warranted, including the need to re-evaluate areas found acceptable because of changes to the model.

High Level Requirements	#	%
One or more Supporting Requirements "not met"	22	43
Not ready for review	1	2
All applicable Supporting Requirements Met	28	55

Supporting Requirements	#	%
Not met	33	19
Not reviewed (not complete)	2	1
Met	139	80
Total	174	100

General Comments About the Reviews of Both Shearon Harris and Oconee Fire PRA Models

The NRC staff reviewed the Shearon Harris and Oconee Unit 3 fire PRA models that will be used as the licensees transition to the NFPA 805 fire protection program. The results of these reviews will help the NRC determine the technical adequacy of each unit's base fire PRA model. During review of each licensee's NFPA 805 amendment request, the NRC staff will focus on how the fire PRA has been upgraded and reviewed, and used to support the NFPA 805 transition.

Neither facility's fire PRA model was complete at the time of the review. The Shearon Harris fire PRA model resembled a scoping study rather than a complete fire PRA model; as a result, the NRC staff recommended that the Shearon Harris licensee perform a full scope industry peer review of the fire PRA model once it has been completed. The Oconee Unit 3 fire PRA model was much more complete than the Shearon Harris model at the time of the review, although the NRC staff was concerned that issues with the internal events PRA model, which forms the basis for the fire PRA, had not been resolved at the time of its review. The NRC staff recommended that the Oconee licensee perform a focused peer review of any portions of the fire PRA model that change substantively between the time of the NRC staff review and completion of the fire PRA model.

Both NRC staff reviews resulted in a similar number of findings and suggestions regarding the Shearon Harris and Oconee Unit 3 PRAs. However, the nature of the findings and suggestions is very different between the two reviews. In the case of Shearon Harris, the NRC staff was concerned with the number of fire PRA areas that could not be assessed because they were incomplete. For Oconee Unit 3, the NRC staff review results are considered to be similar to what one would expect from an industry peer review of a completed fire PRA.

The review team made the following observations as a result of the NRC staff reviews of the Shearon Harris and Oconee Unit 3 fire PRA models:

- The PRA Standard, currently in draft form, provides an appropriate set of requirements to assess the technical adequacy of a fire PRA model.
- Neither licensee's fire PRA model was complete to the point where an industry peer review or NRC staff review could assess its technical adequacy. Neither licensee had completed the *uncertainty and sensitivity analysis* task.
- The fire PRA standard requirements assume a technically adequate internal events PRA model as a starting point for developing a technically adequate fire PRA model. The Oconee plant licensee did not produce documented resolution of internal events PRA model issues.

- The two licensees reviewed had not performed detailed fire modeling to an appropriate level of realism consistent with NUREG/CR-6850⁶.
- Developing a fire PRA for a nuclear facility is a very resource-intensive activity. This is based on neither plant's fire PRA model being complete in spite of the large amount of work that the licensees had performed. As a result, the schedule for completing a fire PRA will remain difficult to predict until more experience is gained by the industry in developing these models.

Although the Shearon Harris and Oconee Unit 3 fire PRA models were not complete at the time of the NRC staff reviews, the reviews provided several benefits to the NRC staff. First, for the fire PRA areas that had been completed, the review provided a reasonable assessment of the base fire PRA model compared to the standard. Second, the review identified areas where the staff will need to focus its review of the base fire PRA model in the future. Finally, the NRC staff effort to review the NFPA 805 license amendment requests from these two plants will rely on the staff's findings as a starting point for assessing the technical adequacy of the licensees' fire PRA models for this application.

Since the NRC staff reviews were conducted, Shearon Harris and Oconee have submitted license amendment requests to transition their fire protection programs to risk-informed, performance-based ones based on the NFPA 805 (dated May 29 and May 30, respectively). These are the first two requests by licensees to make this transition. The staff is currently performing acceptance reviews of these requests, and plans to complete the reviews of the applications by March 2009.

cc: SECY
OGC
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⁶ NUREG/CR-6850, "Fire PRA Methodology for Nuclear Power Facilities," September 2005 (ADAMS Accession Nos. ML052580075 (volume 1) and ML052580118 (volume 2))

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⁶NUREG/CR-6850, "Fire PRA Methodology for Nuclear Power Facilities," September 2005 (ADAMS Accession Nos. ML052580075 (volume 1) and ML052580118 (volume 2))