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UPDATES TO EPRI/NRC-RES FIRE HRA GUIDELINES

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ABSTRACT

Over the past several years, the nuclear power plant (NPP) fire protection community in the United States and overseas has been transitioning towards risk-informed and performance-based (RI/PB) practice in design, operation and regulation. In order to make more realistic decisions for risk-informed regulation, fire probabilistic risk analysis (PRA) methods needed to be improved. To address this need, in 2001, the NRC Office of Nuclear Regulatory Research (RES) and Electric Power Research Institute (EPRI) collaborated under a joint Memorandum of Understanding (MOU), to develop NUREG/CR-6850 (EPRI

101989), “EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities,” a state-of-art Fire PRA methodology. The fire human reliability analysis (HRA) guidance provided in NUREG/CR-6850 included: 1) a process for identification and inclusion of the human failure events (HFEs), 2) a methodology for assigning quantitative screening values to these HFEs, and 3) initial considerations of performance shaping factors (PSFs) and related fire effects that might need to be addressed in developing best-estimate human error probabilities (HEPs). However, NUREG/CR-6850 did not identify or produce a methodology to develop these best-estimate HEPs given the PSFs and the fire-related effects.

In 2007, EPRI and RES embarked upon another cooperative project to develop explicit guidance for estimating HEPs for human error events under fire generated conditions, building on existing HRA methods. It is anticipated that such guidance will be used by the industry as part of transition to the risk-informed, performance-based fire protection rule, 10CFR50.48c, which endorsed National Fire Protection Association (NFPA) 805, “Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants” and possibly in response to other regulatory issues such as multiple spurious operation (MSO) and operator manual actions (OMAs). As the methodology is applied at a wide variety of NPPs, the guidance may benefit from future improvements to better support industry-wide issues being addressed by fire PRAs.

The collaborative project produced a draft report for public comment, “EPRI/NRC-RES Fire Human Reliability Analysis Guidelines,” (NUREG-1921, EPRI TR 1019196). The draft guidelines address the range of fire procedures used in existing plants, the range of strategies for main control room (MCR) abandonment, and the potential impact of fire-induced electrical spurious actuation effects on crew performance. The draft guidelines also present a three tiered, progressive approach for fire HRA quantification. The quantification approaches included are: a screening approach per NUREG/CR-6850 guidance (modified somewhat to clarify certain aspects and to account for long-term events), a scoping approach, and detailed quantification using either EPRI’s Cause Based Decision Tree (CBDT) and HCR/ORE or the NRC’s ATHEANA approach with modifications to account for fire effects.
In the spring of 2010, the joint EPRI/NRC-RES team received public comments on the draft guidelines. These comments were reviewed by the team and are currently being addressed.

Key Words: Human reliability analysis, probabilistic risk assessment, fire.

1 INTRODUCTION AND BACKGROUND

Over the past several years, the nuclear power plant (NPP) fire protection community has been transitioning toward risk-informed and performance-based (RI/PB) practice in design, operation and regulation. To make more realistic decisions for risk-informed regulation, fire probabilistic risk analysis (PRA) methods needed further development. To address this need, in 2001, the U.S. Nuclear Regulatory Commission’s (NRC’s) Office of Nuclear Regulatory Research (RES) and the Electric Power Research Institute (EPRI) collaborated under a joint Memorandum of Understanding (MOU) to develop NUREG/CR-6850 (EPRI 101989)[1], “EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities,” a state-of-art fire PRA methodology. The fire human reliability analysis (HRA) guidance provided in NUREG/CR-6850 included: (1) a process for identification and inclusion of the human failure events (HFEs), (2) a methodology for assigning quantitative screening values to these HFEs, and (3) initial considerations of performance shaping factors (PSFs) and related fire effects that might need to be addressed in developing best-estimate human error probabilities (HEPs). However, NUREG/CR-6850 did not identify or produce a methodology to develop these best-estimate HEPs given the PSFs and the fire-related effects.

In order to address a need for explicit guidance for estimating HEPs for human failure events under fire-generated conditions, EPRI and RES embarked on another cooperative project that resulted in the development of draft NUREG-1921, “EPRI/NRC-RES Fire Human Reliability

Analysis Guidelines" [2]. It is anticipated that this guidance will be used by the industry as part of transition to the risk-informed, performance-based (RI/PB) fire protection rule, 10 CFR 50.48c, that endorsed National Fire Protection Association (NFPA) 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants" and possibly in response to other regulatory issues such as multiple spurious operation (MSO) and operator manual actions (OMAs).

Public comments were received on the joint EPRI/NRC-RES Fire HRA Guidelines in 2010. At present, the project team is working to resolve these comments and produce a final report. This paper summarizes this effort that will ultimately result in a final version of the joint Fire HRA Guidelines.

2 SUMMARY OF PUBLIC COMMENTS

The draft for public comment of the Joint EPRI/NRC-RES Fire HRA Guidelines was published in December 2009. Public comments were accepted through March 2010.

As shown in Table I, there were four organizations that provided public comments on the draft Fire HRA Guidelines: 1) the Boiling Water Reactor Owner's Group (BWROG), 2) EPRI's HRA User's Group (HRA UG), 3) the Pressurized Water Reactor Owner's Group (PWROG), and 4) Exelon. Each comment was tracked by the numbering system used by the commenter. However, for a few cases, a comment was subdivided because multiple issues were raised. Consequently, the total number of public comments to address is two hundred, ninety (290).

Table I. Summary of public comments for the Joint EPRI/NRC-RES Fire HRA Guidelines

Commenter	Number of Comments
BWROG	89
HRA UG	35
PWROG	102
Exelon	64
Total	290

3 PROCESS FOR RESOLVING PUBLC COMMENTS

The joint EPRI/NRC team is currently addressing all public comments through a process of comment categorization and consensus resolution. This process began shortly after the public comment period closed in March 2010. Resolution efforts were interrupted by the need to develop new training materials for a brand new HRA track in the Joint EPRI/NRC-RES Fire PRA Training Course, held in September and October 2010. Recently, comment resolution efforts have resumed and are in-progress as this paper goes to press.

First, the 290 public comments were reviewed by team members. One team member developed an initial classification or grouping by issue. A total of forty-nine (47) different categories of issues were identified. Examples of such issue grouping are:

- acronyms
- ATHEANA
- definition of HFEs
- documentation
- edit
- EPRI Approach
- feasibility
- identification
- operator interviews
- PSFs
- qualitative analysis
- recovery
- spurious indications
- time margin
- timing + fire modeling
- uncertainty
- wording

Of the total number of public comments, seventy-nine (79) represented editorial, rather than technical, concerns. These comments were classified as "edit" or "wording."

Ultimately, except for those comments that addressed the report or approach as a whole, the team decided to address comment resolution by chapter and associated sub-sections. For those comments that were associated with a topic or issue that was common to more than one chapter or sub-section, coordination between the lead authors of affected chapters and/or sub-sections was required. In addition, review comments that the authors collected before the draft report was published (e.g., comments given during the 2008 peer review) continued to be tracked and stored with the more recently collected public comments.

Except for editorial comments, all comments have been discussed by the entire EPRI/NRC-RES team. Many of the public comments received were relatively straightforward and were addressed through brief discussions or by e-mail correspondence. However, there are a number of comments that were more complicated in some way, requiring more extensive team discussion. For the most part, these more complicated comments can be characterized in one of four ways:

1) a change to some important technical aspect of the joint Fire HRA Guidelines was requested,

2) a requested improvement to the joint Fire HRA Guidelines affecting multiple chapters or sub-sections,
3) a solution to a more generic problem in HRA application was requested, or
4) a requested addition or improvement to the joint Fire HRA Guidelines that was beyond the intended scope of this report.

In the next section, the authors provide examples of the comment characteristics above.

4 MAJOR COMMENT CATEGORIES

Although final resolution of public comments is on-going at this time, examples of a few comment categories are presented here, along with preliminary information on how the joint EPRI/NRC-RES team expects to resolve them.

These example comment categories also represent the topics or aspects of the joint Fire HRA Guidelines that the authors expect to be significantly changed from the December 2009 draft report. Most of the other public comments will not require any significant change to the Guidelines.

The example categories of public comments are:

1. re-ordering or re-working of the overall fire HRA process,
2. modification and expansion of guidance on how to assess the feasibility of operator actions,
3. adjustments to the scoping approach, and
4. modification and expansion of the uncertainty analysis guidance.

Each of these comment categories is briefly discussed below.

4.1 Overall Fire HRA Process

The HRA process used in the Fire HRA Guidelines is intentionally similar to other HRA processes (e.g., SHARP1 [3]); reflecting that the basic steps for performing an HRA in support of a fire PRA are the same as for a Level 1, internal events PRA. However, even though it has been nearly two decades have elapsed since SHARP1 was released, few documents have tried to describe in detail what activities are needed to perform HRA process steps. The authors of the Fire HRA Guidelines decided that such detail was necessary in order to:

- support HRA/PRA quality (e.g., as described in the ASME/ANS PRA Standard [4]), and
- address specific needs for fire HRA/PRA (that either are not concerns for internal events HRA/PRA or are of lesser importance).
- ensure the fire HRA guidelines were consistent with the process insights gained from other HRA projects such as the Halden empirical benchmarking and a project to ensure consistency in HRA methods (aka the SRM project).

One consequence of the detail provided in the Fire HRA Guidelines is that material provided sequentially in the report does not match how HRA is practically performed in support of the fire

PRA. For example, in Chapter 2 on "Identification and Definition," the guidance provided addresses a variety of stages in the development of fire PRA, including:

1. initial identification and definition of human failure events (HFEs) when very little is understood about relevant accident scenarios (especially, fire progression), and
2. refinement and final identification and definition of HFEs when information on timing of operator actions and accident progression is available and can be used to decide if an initially defined HFE should be re-defined into two or more HFEs (with different timing considerations).

Although the iterative nature of HRA and PRA is mentioned in multiple locations in the Fire HRA Guidelines, several comments on this topic were received during the public comment period and during the peer review. In addition, these comments sometimes requested conflicting resolutions. For example, one request was to move the qualitative analysis section to an appendix while others thought the guidance ought to be distributed throughout the report.

Also, because concerns about how to logically provide guidance on how to implement an HRA process is generic to HRA applications (i.e., not specific to fire HRA), the authors will likely defer complete resolution of this issue to other HRA research projects. Where possible, clarification has been provided so that the user understands that all information discussed in the Guidelines are not expected to be available early in the overall HRA/PRA development.

4.2 How to Assess Feasibility

Ten (10) public comments were received on the discussion of feasibility assessment, primarily regarding sources of data used during the feasibility assessment. While not all of these comments required substantive response, some did and the authors decided to devote considerable effort to clarifying and expanding the guidance on this topic. For example, it is expected (once final team consensus is reached) that a substantial addition will be made on the topic of feasibility assessments.

Response to public comments on this topic also is expected to result in some modified guidance on this topic. In particular, it was suggested that the Fire HRA Guidelines recognize a larger range of information sources as data sources for the feasibility assessments. For example, job performance measures, timing information obtained from the performance of similar tasks, and well conducted talk-throughs with knowledgeable plant personnel are all potential sources that could be used for feasibility assessments rather solely relying on detailed walk-throughs and demonstrations. The final version of the Fire HRA Guidelines is expected to provide relevant guidance, recognizing that the development of timing and performance information for feasibility assessments can be resource intensive. However, the final guidance also is expected to caution the user that the appropriateness and quality of these different information sources will vary.

4.3 Scoping Approach

The Fire HRA scoping approach is one of three HRA quantification approaches discussed in Chapter 5, "Quantification." Twenty-six (26) public comments on the scoping approach were received.

A range of issues associated with the scoping approach were represented in these comments and, in a few cases, resolution could result in changes to the flowcharts and associated human error probabilities (HEPs) for the endpoints of flowchart branches. Consequently, the authors decided to resolve these comments prior to the development of fire HRA training materials for Joint EPRI/NRC-RES Fire PRA Training Courses in September and October 2010. Overall, two types of modifications to the scoping approach have been made:

1. clarifications in guidance on use of the scoping approach flowcharts and its associated terminology, and
2. changes (only a few) to the flowcharts and associated HEPs.

Also, some comments on the scoping approach were related to the topic of "feasibility assessment." As discussed in the previous sub-section, the authors are taking significant steps to modify and improve the guidance for assessing feasibility, adjusting the demands of the analysis to be commensurate with the needed level of detail.

4.4 Uncertainty Analysis

Eight (8) public comments addressed Chapter 8, "Uncertainty Analysis." The two most substantive categories of comments are related to:

1. the need for better overall guidance to address uncertainties for fire HRA, and
2. the appropriateness of the uncertainty analysis approach for HEPs developed through either the screening or scoping approaches.

The authors of the Fire HRA Guidelines have had preliminary discussions on these comments. In general, the authors have agreed that the uncertainty analysis approach in the Fire HRA Guidelines should:

- be consistent with other guidance on uncertainty analysis (e.g., that provided in References 5 and 6)
- be consistent and recognize on-going research on uncertainty analysis
- be generic to HRA (and, therefore, not a focus for development in the Guidelines), except for identified, fire-specific HRA/PRA needs

However, consensus on the final resolution of these comments is not expected to occur until a team meeting takes place in February 2011.

5 CONCLUSIONS

This paper described the process for addressing public comments on the draft Fire HRA Guidelines and provided some preliminary ideas on how example categories of comments are expected to be resolved.

Although the final version of the joint Fire HRA Guidelines is expected to be published later in 2011, the authors of this paper recognize that additional work in the area of fire HRA is likely to be needed in the future. Methods and approaches for fire HRA will need to expand and mature as advances are made to the overall fire PRA methodology. Also, this current report focuses on HRA issues of generic importance to users, but eventually more plant-specific problems and issues may need to be addressed. Finally, considerable research is being done to support HRA, in general, which may also facilitate future improvement in fire HRA.

6 ACKNOWLEDGMENTS

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