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MEMORANDUM TO: Raj M. Iyengar, Chief
Reactor Engineering Branch
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Office of Nuclear Regulatory Research

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SUBJECT: SUMMARY OF THE JUNE 14, 2022, PUBLIC MEETING WITH EPRI AND STAKEHOLDERS TO DISCUSS USE OF THE EXTREMELY LOW PROBABILITY OF RUPTURE CODE FOR LOSS-OF-COOLANT ACCIDENT FREQUENCY ESTIMATES

The U.S. Nuclear Regulatory Commission (NRC) staff held a meeting on June 14, 2022, with representatives of the Electric Power Research Institute (EPRI) to discuss technical aspects concerning use of the Extremely Low Probability of Rupture (xLPR) probabilistic fracture mechanics (PFM) code to inform loss-of-coolant accident (LOCA) frequency estimates and related regulatory applications.

The agenda and slide presentations for the meeting are available in the NRC's Agencywide Documents Access and Management System (ADAMS) under Accession Numbers ML22133A035 and ML22166A345, respectively. Enclosed is a list of the meeting participants.

A summary of the meeting's discussions follows by agenda topic.

1. Introduction and Opening Remarks

The NRC staff welcomed the participants and covered the agenda and administrative items for the meeting. A senior manager from NRC staff and an EPRI representative then delivered opening remarks. They highlighted the significance of xLPR V2 to both organizations as a modern risk-informed decision-making tool. Additionally, they emphasized that the applications involving the code and interpretation of the results are done independently. It was also noted at the start that the meeting was a purely technical discussion on LOCA frequency estimates using the xLPR code, and that the NRC is not actively soliciting comments towards any regulatory decisions.

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2. Overview of NUREG-1829, “Estimating Loss-of-Coolant Accident (LOCA) Frequencies Through the Elicitation Process”

The NRC staff outlined the LOCA frequency expert elicitation project chronicled in NUREG-1829, which was used as part of the technical basis supporting a proposed revision to Section 50.46 of Title 10 of the *Code of Federal Regulations* (10 CFR 50.46). The NUREG-1829 results are also used in probabilistic risk assessment modeling. The NRC staff also summarized other activities associated with selecting the transition break size (TBS) for the proposed revision to 10 CFR 50.46. This included considerations associated with selecting the TBS, seismic considerations as documented in NUREG-1903 and the development of draft guidance.

3. Predicting Pipe Rupture Frequencies Using xLPR

The NRC staff discussed an initial study conducted in 2019 on whether the xLPR code can be used to confirm pipe rupture frequencies. The results suggested that the pipe break frequencies in NUREG-1829 are conservative. However, additional analyses would be needed for a more robust comparison with the piping break frequencies developed through the expert elicitation effort of NUREG-1829.

4. Example xLPR LOCA Frequency Estimates Compared to NUREG-1829 Expert Elicitation Results

The NRC staff explained a recent further exploration using the xLPR code to generate LOCA frequency estimates and compare those estimates with the expert elicitation results from NUREG-1829. The NRC staff’s study focused on the hot legs of pressurized-water reactors (PWRs), where primary water stress-corrosion cracking (PWSCC) is the primary degradation mechanism of concern. Some key observations from this limited-scope study were the following:

- the xLPR code can be used to develop system- or plant- level LOCA frequency estimates associated with the modeled degradation mechanisms using its current capabilities
- the LOCA frequency estimate results are sensitive to the modeling inputs and assumptions, and these sensitivities can be studied
- leak rate detection has a significant impact

5. Overview and Key Outcomes from Scoping Study on Use of the xLPR Code for Developing LOCA Frequency Estimates

An EPRI representative described the scope of work for a pilot study it conducted using the xLPR code to calculate LOCA probabilities in PWRs as a function of piping line size. The main results reported for this effort were the following:

- LOCA frequencies are higher in lines susceptible to PWSCC
- rupture frequencies have a similar order of magnitude or lower than those in NUREG-1829
- the times from detectable leakage to rupture indicated notable margins for leak-before-break behavior

6. Use of LOCA Frequency Estimates in Fuels Licensing Applications

To provide context on the potential uses of updated LOCA frequency estimates, an EPRI representative presented an overview on the topic of fuel fragmentation, relocation and dispersal (FFRD). He explained that higher burnup fuel, if subjected to elevated temperatures during

accident conditions, can result in FFRD. Industry is pursuing an alternative licensing strategy (ALS) approach that addresses LOCA-induced FFRD in a more realistic manner than conventional approaches. The EPRI representative explained that the ALS does not, however, address FFRD consequences for severe accidents. It references the results of a severe accident phenomena identification and ranking table (PIRT) published in NUREG/CR-7283. For non-piping LOCA events, the failure frequency of the remaining components based on NUREG-1829 or other relevant failure data will be evaluated. The NRC staff raised a question as to what the acceptance criteria would be for such an application.

7. Plans for Full-Scope Study Using the xLPR Code to Develop LOCA Frequency Estimates

A representative from EPRI presented an overview of an ongoing EPRI study to determine the following:

- probability of LOCAs in piping greater than 6 inches nominal pipe size in PWRs
- whether LOCAs may be detected in sufficient time to allow reactor shutdown before rupture

EPRI's objective in this project phase was to perform probabilistic fracture mechanics (PFM) evaluation using xLPR to calculate probabilities of LOCAs in PWRs as a function of pipe size and evaluate the time between detectable leakage and rupture. ERPI is currently gathering input data and preparing input sets for xLPR analyses. EPRI also plans to leverage data from the NRC/RES probabilistic leak-before-break analyses documented in the reports titled: "Probabilistic Leak-Before Break Evaluation of Westinghouse Four-Loop Pressurized-Water Reactor Primary Coolant Loop Piping using the Extremely Low Probability of Rupture Code" (ML21217A088) and in "Probabilistic Leak-Before Break Evaluations of Pressurized-Water Reactor Piping Systems using the Extremely Low Probability of Rupture Code" (ML22088A006). Execution of the additional xLPR analysis cases will begin in summer of 2022 with future publication in an EPRI technical report.

8. Treatment of Non-xLPR-Modeled Degradation Mechanisms and Failure Modes

An EPRI representative concluded the EPRI presentations by outlining plans for treatment of non-xLPR modeled degradation mechanisms and failure modes. The xLPR code only directly models stress-corrosion cracking and fatigue degradation mechanisms. Additional degradation mechanisms considered in NUREG-1829 will need to be considered when benchmarking with xLPR results. This will be explored further in phase 2 of the EPRI study. Nevertheless, these results from xLPR considering PWSCC and fatigue provide valuable information regarding the conservatism or non-conservatism of the NUREG-1829 LOCA frequencies.

9. Analysis Schedule and Engagement Opportunities

EPRI's analysis schedule was discussed under topic items 6 and 7. Concerning future engagement, the NRC staff took the following action items from the meeting:

- review the current NRC/RES-EPRI memorandum of understanding for cooperative research to determine whether it would accommodate future discussions and sharing of research information
- schedule a follow-on public meeting later in the year to discuss results from EPRI's full-scope study

10. Public Question and Answer

The NRC staff provided opportunities for members of the public to ask questions and provide comments. There were none.

The NRC staff provided EPRI with an opportunity to review a draft of this meeting summary.EPRI comments were incorporated as appropriate.

Enclosure:
As stated

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DATE	06/22/2022	06/22/2022

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Participant List

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S. Min	NRC
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D. Rudland	NRC
A. Buford	NRC
M. Mitchell	NRC
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B. Smith	NRC
M. Benson	NRC
C. Parker	NRC
E. Haywood	NRC
J. Messina	NRC
J. Tsao	NRC
K. Bucholtz	NRC
M. Wentzel	NRC
K. Heller	NRC
L. James	NRC
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C. Dame	MPR Associates
D. Shim	EPRI
R. Daum	EPRI
C. Sallaberry	Emc2
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