Mitman, Jeffrey

From: Mitman, Jeffrey
Sent: Tuesday, September 07, 2010 9:58 AM
To: Ferrante, Fernando
Subject: IN-Dam Failure Rate v 0 jtm.docx
Attachments: IN-Dam Failure Rate v 0 jtm.docx

My preliminary comments.

B-120

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555-0001

NRC INFORMATION NOTICE 2010-xx: APPLICABILITY OF HISTORICAL DAM FAILURE FREQUENCY ESTIMATES IN PROBABILISTIC RISK ASSESSMENTS

ADDRESSEES

All holders of an operating license or construction permit for a nuclear power reactor issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to alert addressees of a potentially non-conservative dam failure frequency estimate used in external flooding analysis that originated in reference documents published in the 1980s and was adopted by licensees in their probabilistic risk assessment (PRA).

Using a non-conservative dam failure frequency may result in underestimating the risks to the plant associated with external flooding or loss of heat sink from the failure of upstream and/or downstream dams or levees. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to correct any error resulting from these reference documents. However, suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

The NRC staff recently identified a potentially non-conservative value for dam failure frequency estimates previously published in documents related to PRA for US nuclear power plants. Analysis performed in a PRA study titled "NSAC/60 Oconee PRA: A Probabilistic Risk Assessment of Oconee Unit 3" by the Nuclear Safety Analysis Center (NSAC) of the Electric Power Institute (EPRI) and participating utilities (NSAC,1984) has been used by licensees performing external flooding analyses to evaluate vulnerabilities due to potential dam failure events. A subsequent publication by the US NRC on external event contributors to overall risk for the U.S. nuclear power plants also refers directly to the NSAC/60 study on the subject of dam failure frequency estimates (USNRC, 1987).

Published in 1984, NSAC/60 provided an estimate for the dam failure frequency of the Jocassee Dam as part of the external flooding analysis for ~~ONS~~ Oconee Nuclear Station Unit 3 PRA. The

framework used in NSAC/60 to develop this estimate was the compilation of historical dam failure events and operational years deemed applicable to Jocassee Dam characteristics (a large, modern rockfill embankment dam). Assumptions were made to screen out the applicable failure events which parsed the information available when the study was published by (i) dam composition, (ii) construction completion date, and (iii) failure modes. A mathematical equation modeling a decrease in generic dam failure rates with an increase in operational dam-years was assumed to reflect improvements to methods of design and construction. A Bayesian analysis using historical dam failures was then performed to estimate the annual failure frequency at the time the analysis was performed (1981) and associated uncertainty range for dams built within different time periods: 1900 – 1981, 1940 – 1981, ~~1960~~and 1960 – 1981). The median annual failure frequencies obtained in NSAC/60 are listed as 2.3 x 10^{-5}/year, 1.6 x 10^{-5}/year, and 1.4 x 10^{-5}/year respectively. This study explicitly recognized the challenge in collecting sufficient historical information based on the scarcity of the data applicable to the specific dam characteristics considered, as well as the complexity of the actual phenomena controlling dam failures and its potential impacts to a nuclear power plant site. Subsequently, [add title] NUREG/CR-5042 ~~mentioned~~ reported bounding calculations with results of "10^{-6}/year or even smaller" for modern well-engineered dams and a range of values between "10^{-4}/year and 10^{-5}/year," referring to NSAC/60 in both cases (USNRC, 1987).

The NRC staff recently noted that many assumptions in the dam failure rate estimation approach used in NSAC/60 are strongly dependent upon the completeness and accuracy of the dam data used and the criteria for including or excluding certain failure events from the set deemed to be applicable to characteristics specific to the dam considered in NSAC/60. In particular, the failure frequency derived in NSAC/60 was considered to be representative of failure modes resulting from causes other than hydrologic (e.g., severe precipitation), and seismic events. In effect, this choice of exclusions eliminates the majority of failure modes that has been historically observed for dams. Additionally, the phenomena associated with non-hydrologic, non-seismic (e.g., internal erosion/degradation) events was further screened for other ~~historical~~ failures modes not deemed applicable based on design considerations also specific to the Jocassee dam ~~considered in the study~~.

Based on this reference, the NRC staff performed a literature reviewe~~d an extensive literature~~ on generic failure rate estimates. This included: an extensive analysis derived from historical evidence for the US and the international population of dams, ~~e.g.,~~ Baecher et al (1980)~~;~~ Martz and Bryson (1982)~~;~~ ICOLD (1995)~~;~~ Foster (2000a)~~;~~ Foster et al (2000b)~~;~~ Donnelly (2004)~~;~~ and USBR (2010). Additionally, NRC staff accessed currently available US databases for both the historical dam failure events and the existing population of US dams (primarily, the National Inventory of Dams maintained by the US Army Corps of Engineers and the National Performance of Dams Program by Stanford University) that provide more complete and accurate information than available when NSAC/60 was ~~licensees~~ initially prepared ~~their PRA for external events~~. Finally, consideration was given to current state-of-art methodologies in risk assessment of dams published by multiple sources, including federal agencies such as the US Department of Interior's Bureau of Reclamation (USBR, 1999; USBR, 2003).

The information available from the sources mentioned above provides significant evidence that dam failure frequencies considerably lower than 10^{-4}/year may not be justifiable based on

historical dam performance~~operating experience~~ alone due to issues such as incompleteness of failure event descriptions (e.g., construction year of failed dam), variability on site-specific characteristics (i.e., hydrologic, geologic, and operational), and inconsistencies on definitions used in the databases (e.g., dam types). These challenges extend to the consideration of breach parameters, flood routing analyses, and effects of the flood waters at the nuclear power plant site; as far as historical data alone is concerned. For example, generic failure frequency values may not account for site-specific features such as the existence of multiple dams upstream or downstream, and potential activation of failure modes in dams which have never been filled beyond a certain operational reservoir level (e.g., first-fill scenarios); which may counteract conservative assumptions in the use of data. These considerations recognize that data available in databases is useful in deriving bounding values and approximate estimates, but that the justification for its use in obtaining significantly lower values that the established averages may not be conservative when the proximity and capacity of dams upstream and/or upstream of a nuclear power plant may suggest more than minimal risk contributions.

DISCUSSION

REFERENCES

Nuclear Safety Analysis Center/Electric Power Research Institute, "NSAC-60 Oconee PRA: A Probabilistic Risk Assessment of Oconee Unit 3," Palo Alto, CA, 1984.

U.S. Nuclear Regulatory Commission, "Evaluation of External Hazards to Nuclear Power Plants in the United States," NUREG/CR-5042, Lawrence Livermore National Laboratory, December 1987, ADAMS Accession No. ML062260222.

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Baecher, G. B., M. E. Paté, and R. De Neufville (1980), "Risk of Dam Failure in Benefit-Cost Analysis," *Water Resource Research*, 16(3), 449–456.

Martz, H.F., and M.C. Bryson (1982), "Predicting Low-Probability/High-Consequence Events," Proceedings of the Workshop on Low-Probability/High-Consequence Risk Analysis, June 15-17, 1982, Arlington, Virginia.

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U.S. Bureau of Reclamation, "A Framework for Characterizing Extreme Floods for Dam Safety Risk Assessment," U.S. Department of the Interior, Technical Service Center, Denver, CO, 1999.

U.S. Bureau of Reclamation, "Dam Safety Risk Analysis Methodology," Version 3.3.1, U.S. Department of the Interior, Technical Service Center, Denver, CO, 2003.

U.S. Bureau of Reclamation, "Dam Safety Risk Analysis Best Practices Training Manual," Version 2.0, U.S. Department of the Interior, Technical Service Center, Denver, CO, 2010.

CONTACT

This information notice requires no specific action or written response. Please direct any questions about this matter to the technical contact listed below.

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Note: NRC generic communications may be found on the NRC public Web site, http://www.nrc.gov, under Electronic Reading Room/Document Collections.

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