POLICY ISSUE
INFORMATION

April 13, 2004 SECY-04-0060

FOR: The Commissioners

FROM: William D. Travers
Executive Director for Operations

SUBJECT: LOSS-OF-COOLANT ACCIDENT BREAK FREQUENCIES FOR THE OPTION III RISK-INFORMED REEVALUATION OF 10 CFR 50.46, APPENDIX K TO 10 CFR PART 50, AND GENERAL DESIGN CRITERIA (GDC) 35

PURPOSE:

To inform the Commission of the updated preliminary loss-of-coolant accident (LOCA) frequency estimates for use in the Option III risk-informed reevaluation of 10 CFR 50.46, Appendix K to 10 CFR Part 50, and GDC 35 and to summarize the technical basis for these frequencies. These frequencies were required by the staff requirements memorandum (SRM) to SECY-02-0057, "Update to SECY-01-0133, Fourth Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.46 (ECCS Acceptance Criteria)," and provide one input for redefining the design basis break size in the 10 CFR Part 50. The other technical and policy issues associated with the break size redefinition are discussed in SECY-04-0037, "Issues Related to Proposed Rulemaking to Risk-Inform Requirements Related to Large Break Loss-of-Coolant Accident (LOCA) Break Size and Plans for Rulemaking on LOCA with Coincident Loss-of-Offsite Power."

CONTACT: Rob Tregoning, RES
301-415-6657
Lee Abramson, RES
301-415-6180

The Commissioners

BACKGROUND:

The Commission issued a SRM in response to SECY-02-0057 on March 31, 2003. This SRM provided direction on the four major technical areas associated with the emergency core cooling system (ECCS) requirements: ECCS acceptance criteria, ECCS reliability, ECCS evaluation methods, and break size redefinition. The current design-basis break size requirements are used to demonstrate the acceptability of the ECCS by analyzing a failure in the worst possible location using the break size that results in the highest peak core cladding temperature. This analysis must consider break sizes up to and including a double-ended guillotine break (DEGB) of the largest pipe in the reactor coolant system. The SRM directed the staff to consider a risk-informed revision of this design-basis requirement.

The SRM also directed the staff to reevaluate the passive system LOCA frequencies and use these to form part of the technical basis supporting subsequent changes in the design basis break size. The SRM provided the following guidance to the staff with respect to this reevaluation:

1. Develop LOCA frequency distributions by combining relevant service history data with probabilistic fracture mechanics insights using expert judgment.

2. Provide a comprehensive LOCA failure analysis and frequency estimation for piping and nonpiping contributions.

3. Develop realistically conservative estimates, with appropriate margin for uncertainty.

4. Credit leak-before-break (LBB) considerations only in conjunction with the establishment by a licensee of reliable and comprehensive means to detect primary system leaks of the relevant size.

5. Use a 10-year period for the estimation of LOCA frequency distributions, with re-estimation every 10 years and a review of new types of failures every 5 years.

This Commission paper provides the staff's response to this direction.

DISCUSSION:

This section summarizes the process employed to develop the LOCA frequency estimates. The discussion includes the objective and scope of the effort, the general approach followed, and the results obtained from the elicitation process. Additional details of this process are provided in the attachment.

Objective and Scope

The objective of the study was to develop piping and nonpiping passive system BWR and PWR LOCA frequency distributions as a function of rupture size for the present and future operating periods. The study was solely focused on determining frequencies of LOCAs that initiate by unisolable primary system failures. This focus is consistent with current use of these frequencies in probabilistic risk assessment (PRA) analysis. Consequential failures of the primary side due to either secondary side failures or failures of other plant structures were not

considered. Previous evaluations of seismic-induced large LOCA piping failures have shown them to not be significant. However, it should be noted that those evaluations have not explicitly addressed degradation. This study primarily considered normal plant operational cycles and loading histories consistent with current internal event PRAs. A complete assessment of risk from all sources is necessary when determining appropriate ECCS requirements.

The future plant operating characteristics were assumed to be essentially consistent with past operating experience. The effects of operating profile changes were not considered due to the uncertainties associated with particular changes and the potential ramifications with respect to degradation-related LOCA frequencies. For instance, changes in plant performance and operating characteristics (e.g., temperature, environment, flow rate) as a result of power uprate could impact future LOCA frequencies. The 5-year review of these LOCA frequency estimates will provide confirmation that neither operating condition changes nor the emergence of new degradation mechanisms undermine the technical basis of these current LOCA frequency estimates. The degradation-related LOCA frequency distribution will be updated, as necessary, every 10 years to account for any changes.

Approach

To develop these estimates, expert elicitation was used to evaluate service history data in light of probabilistic fracture mechanics insights. Expert elicitation is a formal process for providing quantitative estimates for the frequency of physical characteristics of phenomena when the required data is sparse and when the subject is too complex to adequately model. Formal elicitation is a well-established PRA tool. There is precedence for using formal elicitation as the basis for technical evaluation. Examples include NUREG-1150, “Reactor Risk Reference Document”; determination of flaw density and size distributions in reactor pressure vessels for the pressurized thermal shock rule revision; evaluation of the high-level waste repository; and probabilistic seismic hazard curve analysis. See the attachment for more detail.

The elicitation was structured to make present estimates of the degradation-related LOCA frequencies and assess how they could be affected in the future by continued plant aging. Past assessments have lacked either a suitable nuclear experience base or an accounting of possible service degradation. The present assessment extends relevant nuclear operating experience using expert opinion of service degradation effects pertaining specifically to nuclear power plants. Aging effects were evaluated by considering the synergistic interaction among material, geometry, loading history, environment, and degradation mechanisms for specific piping systems and nonpiping components. The effect of mitigation on curbing the effects of aging was also a principal consideration. Mitigation measures considered include inservice inspection, leak detection, water chemistry, and other specific practices. The likelihood that aging mechanisms will result in a precursor leak prior to failure (e.g., LBB) was also addressed.

The expert elicitation process consisted of a number of steps. To begin, the facilitation team identified the technical issues to be evaluated and selected a panel of 12 experts. Each panel member has at least 25 years of relevant technical expertise. The panel also represented a wide range of organizational affiliations. The attachment to this memorandum lists the panel members. At its initial meeting, the panel discussed the technical issues and developed a final approach to quantifying the effect of these issues. The facilitation team and panel then developed background technical information and prepared the elicitation questionnaire. A

second meeting was held to review and refine the technical information and questionnaire. Each individual panel member then did a separate analysis to answer the questionnaire.

The facilitation team met separately with each panel member in a day-long elicitation session. At this session, each panel member answered the elicitation questionnaire by providing quantitative estimates and a qualitative rationale to support the judgments of the most important LOCA challenges. Each panel member also provided the uncertainty associated with these estimates. The project staff then compiled the panel's responses and developed preliminary estimates of the LOCA frequencies. Along with the rationales, the preliminary estimates were presented to the panel at a final meeting. Panel members were invited to fill in gaps in their questionnaire responses and, if desired, to modify their responses.

Results

The results of this elicitation provide a comprehensive assessment of degradation-related LOCA frequencies. The results reflect the inherent uncertainty in estimating rare events. Panel members provided their median responses and associated uncertainty bounds for each question. The median responses and uncertainty bounds were used to obtain mean LOCA frequency estimates. Individual uncertainty bounds are used to develop the 5th and 95th percentile estimates for the LOCA frequency distributions. Variability in the panel results is reflected in uncertainty bounds provided for each estimate in the attachment.

The degradation-related LOCA frequencies are estimated for six rupture size categories. The LOCA definitions are similar to historical small break (SB), medium break (MB), and large break (LB) flow rate definitions for the first three LOCA categories. Additionally, three larger LOCA categories were defined in the elicitation within the classical LB LOCA regime. The purpose of these additional categories was to examine trends with increasing break size, up to and including a DEGB of the largest reactor coolant system piping.

The important qualitative technical issues identified by the individual panel members were reasonably consistent. However, the quantitative estimates of the importance of these issues differed substantially among panel members. This is expected given the uncertainties in assessing degradation-related LOCA frequencies. The panel's mean and 95th percentile LOCA frequency estimates are presented in Table 1.

Table 1: Preliminary Degradation-Related LOCA Frequencies for Ensuing 10 Years

LOCA Size (gpm)	Effective Break Size (in)	BWR Plants		PWR Plants	
		Mean (cal-yr^{-1})	95th (cal-yr^{-1})	Mean (cal-yr^{-1})	95th (cal-yr^{-1})
100 - 1,500	½ - 2	3 E-04	1 E-03	6 E-03	2 E-02
1,500 - 5,000	2 - 3	1 E-04	4 E-04	2 E-04	8 E-04
5,000 - 25,000	3 - 7	2 E-05	7 E-05	1 E-05	5 E-05
25,000 - 100,000	7 - 18 (BWR) 7 -14 (PWR)	4 E-06	2 E-05	2 E-06	9 E-06
100,000 - 500,000	18 - 41 (BWR) 14 - 31 (PWR)	2 E-06	6 E-06	2 E-08	8 E-08
> 500,000	> 41 (BWR) > 31 (PWR)	2 E-09	9 E-09	2 E-08	7 E-08

Notes: 1: Final estimates subject to change resulting from peer review, stakeholder feedback, and sensitivity analysis.
2: Sensitivity analysis is ongoing to examine robustness of estimates due to analysis assumptions.

The Commissioners

The frequencies are provided as a function of both the expected flow rate and corresponding effective break size ranges. These frequencies are applicable for the ensuing 10-year period. Additional results are discussed in the attachment. These frequency distributions represent generic BWR- and PWR-specific frequencies for the commercial fleet. The results are generally comparable to NUREG/CR-5750 estimates for SB, MB, and LB LOCAs.

TECHNICAL ISSUES:

These degradation-related LOCA frequencies form a necessary, but not sufficient, component of the technical basis that will support the risk-informed revision of the ECCS regulation. There are additional steps required in order to select an alternative design-basis break size.

1. Frequencies associated with consequential LOCAs (e.g., seismic events) and other initiators (e.g., stuck open valves, transients) need to be assessed along with the degradation-related LOCA frequencies (Table 1), as discussed below.

2. Thermal-hydraulic analyses are necessary to investigate plant system response as a function of break size and location and develop appropriate success criteria, particularly for accident management.

3. The combined LOCA frequencies and success criteria need to be used as input to PRA models to understand risk and implications resulting from postulated events and plant operational changes.

A more thorough discussion of technical and policy issues associated with the development of revised design basis break size is contained in SECY-04-0037. The remaining technical work described above will be undertaken once additional Commission guidance is provided as requested in SECY-04-0037.

CONTINUING STAFF EFFORTS:

The formal elicitation of the experts has been completed. The remaining elicitation-related work will focus on project documentation, presentation of results to the ACRS and affected stakeholders, and peer review. This elicitation-related work will be completed by the end of 2004. In addition, probabilistic LOCA and fracture mechanics computer models are being developed to provide a technical basis for the next LOCA frequency estimation in 10 years as required by the SRM. Some initial results from these models will be available over the next 18 months. The evaluation of plant system response to postulated breaks, risk assessments of potential plant changes, and consideration of consequential LOCA frequency contributions are also currently ongoing in the Office of Nuclear Regulatory Research. A short-term scoping effort will be conducted to determine whether seismic LOCAs in degraded piping provide significant LOCA frequency contributions to those summarized in Table 1. The scope and schedule with remaining activities necessary to develop the technical basis will be determined after Comission guidance is provided for rulemaking options as described in SECY-04-0037.

The Commissioners

RESOURCES:

There are resources in the budget to continue the staff activities necessary to complete the elicitation process and to continue confirmatory research supporting these degradation-related LOCA frequency estimates in FY2004. The principal resource allocation in subsequent years will be used for developing probabilistic LOCA and fracture mechanics computer models for planned use in reevaluating LOCA frequencies every 10 years. These computer models are needed for other applications as well. The estimated resources for the elicitation-related activities for FY2005 and FY2006 are 0.5 FTE and $500K each year for RES. Required resources to complete part of the technical basis and rulemaking efforts are discussed in SECY-04-0037. Resources to complete additional required technical basis work will be identified once Commission guidance is provided for SECY-04-0037. These resources will be budgeted through the PBPM process.

COORDINATION:

The Office of the General Counsel has reviewed this paper and has no legal objections. The Office of the Chief Financial Officer has reviewed this paper for resource implications and has no objections.

/RA Carl J. Paperiello Acting For/

William D. Travers
Executive Director
for Operations

Attachment: 10 CFR 50.46 LOCA Frequency Development

The Commissioners

RESOURCES:

There are resources in the budget to continue the staff activities necessary to complete the elicitation process and to continue confirmatory research supporting these degradation-related LOCA frequency estimates in FY2004. The principal resource allocation in subsequent years will be used for developing probabilistic LOCA and fracture mechanics computer models for planned use in reevaluating LOCA frequencies every 10 years. These computer models are needed for other applications as well. The estimated resources for the elicitation-related activities for FY2005 and FY2006 are 0.5 FTE and $500K each year for RES. Required resources to complete part of the technical basis and rulemaking efforts is discussed in SECY-04-0037. Resources to complete additional required technical basis work will be identified once Commission guidance is provided for SECY-04-0037. These resources will be budgeted through the PBPM process.

COORDINATION:

The Office of the General Counsel has reviewed this paper and has no legal objections. The Office of the Chief Financial Officer has reviewed this paper for resource implications and has no objections.

/RA Carl J. Paperiello Acting For/

William D. Travers
Executive Director
for Operations

Attachment: 10 CFR 50.46 LOCA Frequency Development

Distribution:
T. Clark L. Reyes MEB r/f DET r/f
WITS 200300047
RES# 2003073
PACKAGE: ML040860198
SECY PAPER: ML040860129
ATTACHMENT: ML040860166
DOCUMENT NAME: G:/Tregoning/SECY.March2004 rev10wpd **PARALLEL CONCURRENCE**
OAR in ADAMS? (Y or N) Y ADAMS ACCESSION NO:ML040860129 TEMPLATE NO. RES: SECY-012
Publicly Available? (Y or N) Y DATE OF RELEASE TO PUBLIC SENSITIVE? N

To receive a copy of this document, indicate in the box: "C" = Copy without attachment/enclosure "E" = Copy with attachment/enclosure "N" = No copy

*see previous concurrence

OFFICE	Tech Edit		RES/DET/MEB		RES/DET/MEB		RES/DET	
NAME	P. Garrity*		R. Tregoning*		N. Chokshi*		M. Mayfield*	
DATE	03/24/04		03/12/04		03/12/04		03/24/04	

OFFICE	RES		OCFO		OGC		NRR:D	
NAME	J. Strosnider*		D. Drucker*		S. Treby/NLO*		B. Sheron for J. Dyer*	
DATE	03/25/04		03/23/04		03/24/04		03/25/04	

OFFICE	RES		OEDO					
NAME	A. Thadani*		W. Travers					
DATE	03/26/04		04/13/04					

The Commissioners

OFFICIAL RECORD