UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

September 4, 2008

MEMORANDUM TO: Members
Advisory Committee on Reactor Safeguards

FROM: Girija Shukla, Senior Program Manager **/RA/**
ACRS

SUBJECT: CERTIFICATION OF THE MINUTES OF THE MEETING OF THE ACRS SUBCOMMITTEE ON RELIABILITY AND PRA, NOVEMBER 27, 2007—ROCKVILLE, MARYLAND

The Subcommittee Chairman has certified the minutes of the subject meeting, dated November 27, 2007, as the official record of the proceedings of that meeting. A copy of the certified minutes is attached.

Attachment: As stated

Electronic cc: E. Hackett
S. Duraiswamy
C. Santos

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MEMORANDUM TO: Girija Shukla, Senior Program Manager
ACRS

FROM: George E. Apostolakis, Chairman
Reliability and PRA Subcommittee

SUBJECT: CERTIFICATION OF THE MINUTES OF THE MEETING OF THE ACRS SUBCOMMITTEE ON RELIABILITY AND PRA, NOVEMBER 27, 2007—ROCKVILLE, MARYLAND

I do hereby certify that, to the best of my knowledge and belief, the minutes of the subject meeting, dated November 27, 2007, are an accurate record of the proceedings for that meeting.

/RA/

George E. Apostolakis Subcommittee Chairman

September 4, 2008
Date

Certified by: G. Apostolakis Issued: 3/21/2008
Certified: 9/4/2008

MEETING MINUTES
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
MEETING OF THE ACRS SUBCOMMITTEE ON
RELIABILITY AND PRA
NOVEMBER 27, 2007—ROCKVILLE, MARYLAND

INTRODUCTION

The Advisory Committee on Reactor Safeguards (ACRS) Subcommittee on Reliability and PRA held a meeting on November 27, 2007, at the headquarters of the U.S. Nuclear Regulatory Commission (NRC) in Room T-2B3, 11545 Rockville Pike, Rockville, MD. The purpose of this meeting was to review the NUREG-1829, “Estimating Loss-of-Coolant Accident (LOCA) Frequencies Through The Elicitation Process,” and NUREG-XXXX, “Seismic Considerations for the Transition Break Size.” Mr. Girija Shukla was the designated federal official for this meeting. The subcommittee received no written statements or requests for time to make oral statements from the public. The subcommittee chairman convened the meeting at 8:30 a.m. on November 27, 2007, and adjourned at 4:45 p.m.

These NUREG reports on the expert elicitation and the seismic report directly support the risk-informed ECCS rule (10 CFR 50.46a). The last interaction between the Committee and the staff on this rule was the ACRS letter of November 16, 2006 that was highly critical of both the staff's draft final rule and the Commission guidance upon which the rule was based. Due to the significance of the ACRS comments and recommendations, the staff sought updated Commission guidance in SECY-07-0082, dated May 16, 2007. The Commission provided updated guidance in an SRM dated August 10, 2007.

BACKGROUND

The Subcommittee earlier reviewed the draft NUREG report, "Estimating Loss-of-Coolant Accident (LOCA) Frequencies through the Elicitation Process," during a meeting on November 16, 2004. During the 518th meeting on December 2-4, 2004, the Committee reviewed the draft NUREG report and recommended that it should be revised prior to being issued for public comment.

During the 520th meeting on March 3-5, 2005, the Committee reviewed the revised draft NUREG report and recommended that the revised draft NUREG report should be issued for public comment. During the 537th meeting on November 1-3, 2006, the Committee reviewed the proposed draft final rule to risk-inform 10 CFR 50.46 and recommended, in part, that NUREG-1829 should be completed before the revised rule is issued.

NUREG-1829 was completed and issued for public comments and comments have been incorporated in the report. This NUREG will be finalized after the ACRS review.

- **NUREG-1829, "Estimating Loss-of-Coolant Accident (LOCA) Frequencies Through the Elicitation Process"**

In a staff requirements memorandum (SRM) dated March 31, 2003, the Commission directed the staff to develop a risk-informed alternative to the current requirements in 10 CFR 50.46 related to the analysis of the performance of ECCS during LOCAs. The focus of this effort is the selection of a risk-informed transition break size (TBS) for the alternative design-basis LOCA. In an SRM dated July 1, 2004, the Commission directed the staff to use LOCA frequencies derived from an expert-opinion elicitation process, supported by historical data and fracture mechanics and other relevant information to determine an appropriate alternative break size. This alternative break size could be the break size that has a mean frequency of occurrence of 1 05 per reactor year.

Expert-opinion-based probability distributions of uncertain quantities have been used extensively in probabilistic risk assessments (PRAs) starting with WASH-1400. The NUREG-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," dated December 1990, studies formalized the process of elicitation and utilization of expert judgments.

Loss-of-coolant accident (LOCA) frequencies (i.e., the estimated frequencies of pipe rupture as a function of pipe size) are used in a variety of regulatory applications, including PRA. Currently, the NRC is using such information to develop a risk-informed alternative to the ECCS requirements in 10 CFR 50.46. Current requirements consider pipe breaks in the reactor coolant pressure boundary, up to and including breaks equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system. One aspect of this activity is to evaluate the technical adequacy of redefining the design-basis break size (the largest pipe size described in 10 CFR 50.46) to a smaller size that is consistent with the estimated frequency of pipe failures as a function of pipe size.

To provide the technical basis for a risk-informed definition of the design-basis break size, this study developed LOCA frequency estimates using an expert elicitation process. This process consolidated service history data and insights from probabilistic fracture mechanics studies with knowledge of plant design, operation, and material performance. This elicitation process is well-recognized for quantifying phenomenological knowledge when modeling approaches or data are insufficient. The process used in this study is an adaptation of the formal expert judgment process used in NUREG-1150.

The results from the expert elicitation provide separate LOCA frequency estimates for piping and nonpiping passive systems, as a function of effective break size and operating time through the end of license extension, for both boiling-water and pressurized-water reactors. In addition, this study considered the sensitivity of the results to various analysis approaches. The greatest sensitivity, and therefore the greatest uncertainty, is a function of the method used to aggregate the individual panelists' estimates to obtain group estimates. The ranges of results from the sensitivity analyses have been used as a baseline for defining the transition break size in the proposed risk-informed alternative to 10 CFR 50.46.

- **NUREG-XXXX, "Seismic Considerations for the Transition Break Size"**

This report has been issued for public comments and comments have been incorporated in the report. This report will be finalized after the ACRS review.

The NRC staff has been considering revision of the regulatory requirements for the ECCS, as set forth in 10 CFR 50.46; Appendix K to 10 CFR Part 50; and General Design Criterion (GDC) 35. In particular, those requirements state that the ECCS shall be sized to provide adequate makeup water to compensate for a break of the largest diameter pipe in the primary system [i.e., the so-called "double-ended guillotine break" (DEGB)].

Consequently, in order to risk-inform the break size, the NRC staff proposed the concept of transition break size (TBS). In addition, the NRC developed pipe break frequencies as a function of break size using an expert elicitation process for degradation-related pipe breaks in reactor coolant systems of typical boiling- and pressurized-water reactors. That elicitation focused on determining event frequencies that initiate by unisolable primary side failures that can be exacerbated by material degradation with age under normal operating conditions. The purpose of this study was to assess potential seismic effects on the postulated TBS, and to provide information to facilitate review and comment regarding the proposed risk-informed revision of ECCS requirements in 10 CFR 50.46. Thus, this report evaluates the seismic effects, using different approaches to evaluate flawed and unflawed piping, and indirect failures of other components and component supports that could lead to piping failure.

DETAILS OF THE DOCUMENTS REVIEWED:

- **NUREG-1829, "Estimating Loss-of-Coolant Accident (LOCA) Frequencies Through the Elicitation Process"**

The ECCS requirements are contained in 10 CFR 50.46, Appendix K to part 50, and GDC 35. Consideration of an instantaneous break with a flow rate equivalent to a double-ended guillotine break (DEGB) of the largest primary system in the plant generally provides the limiting condition in the required ECCS analysis. However, the DEGB is widely recognized as an extremely unlikely event. Therefore, the NRC is developing a risk informed revision of the design-basis break size requirements for operating commercial nuclear power plants. A central consideration in selecting a risk-informed design basis break size is an understanding of the LOCA frequency as a function of break size.

LOCA frequency estimates have been developed using an expert elicitation process to consolidate service history data and insights from PFM studies with knowledge of plant design, operation, and material performance. This elicitation process is well-recognized for quantifying phenomenological knowledge when data or modeling approaches are insufficient. Separate BWR and PWR piping and non-piping passive system LOCA frequency estimates have been developed as a function of effective break size and operating time through the end of license extension. The elicitation focused solely on determining event frequencies that initiate by unisolable primary system side failures that can be exacerbated by material degradation with age. The expert elicitation process employed in this study is an adaptation of the formal expert judgment process used in NUREG-1150. This current elicitation process included the decomposition of the complex technical issues which impact LOCA frequencies into

fundamental elements in order to more easily assess these important contributing factors. The elicitation process required each member of the elicitation panel to qualitatively and quantitatively assess these LOCA contributing factors and also indicate their uncertainty in this assessment. This information was collected from each panelist in an individual elicitation session.

The qualitative insights provided by the panel members are reasonably consistent. Most panelists agreed that a complete break of a smaller pipe, or non-piping component, is more likely than an equivalent size opening in a larger pipe, or component. Many panelists thought that aging may have the greatest effect on intermediate diameter (6 to 14-inch nominal diameter) piping systems due to the large number of components within this size range and the fact that this piping generally receives less attention than larger diameter piping and is harder to replace than the more degradation-prone smaller diameter piping.

Frequency estimates are not expected to change dramatically over the next fifteen years, or even the next thirty-five years. While aging will continue, the consensus is that mitigation procedures are in place, or will be implemented in a timely manner, to alleviate possible LOCA frequency increases.

The quantitative responses were analyzed separately for each panel member to develop individual BWR and PWR total LOCA frequency estimates of the mean, median, 5th and 95th percentiles. The LOCA frequencies for the individual panelists were then aggregated to obtain group LOCA frequency estimates, along with measures of panel diversity. While there was general qualitative agreement among the panelists about important technical issues and LOCA contributing factors, the individual quantitative estimates are much more variable. Additionally, as the LOCA size increased, the panel members generally expressed greater uncertainty in their predictions, and the variability among individual panelists' estimates increased. Both trends are expected given the underlying scientific uncertainty.

The elicitation LOCA frequency estimates are generally much less than the prior WASH-1400 estimates and more consistent with the NUREG/CR-5750 estimates. The small break (SB) LOCA frequency estimates are similar once the steam generator tube rupture frequencies are added to the NUREG/CR-5750 PWR results. The elicitation medium break LOCA estimates are higher than the NUREG/CR-5750 estimates by factors of approximately 4 and 20 for BWR and PWR plant types, respectively. These increases are partly due to PWSCC of piping and nonpiping (CRDM) components, as well as the general aging concerns with piping in this size range. The NUREG/CR-5750 LB LOCA frequency estimates, most comparable to the elicitation LOCA Category 4, tend to be slightly higher (approximately a factor of 3) than the current elicitation results.

Sensitivity analyses were conducted to examine the robustness of the quantitative results to the analysis procedure. These sensitivity analyses investigated the effect of distribution shape on the mean, correlation structure, panelist overconfidence, panel diversity measure, and aggregation method on the estimated parameters. The mean calculation used a split log normal distribution truncated at the 99.9th percentile to obtain reasonably conservative values. The correlation structure assumed maximal correlation, which the NUREG states is reasonably representative of the elicitation structure and provides conservative 95th percentile estimates. However, based on selected Monte Carlo simulations, assuming an independent correlation

structure results in larger median and 5th percentile estimates. The means are unaffected by the correlation structure. The analysis procedure adjusted some panelists' responses that had relatively narrow uncertainty ranges to account for a known tendency for people to be overconfident when making subjective judgments.

Sensitivity analyses examined the effects of other overconfidence adjustments as well as no adjustment of the nominal subjective confidence levels supplied by the panelists. The NUREG states that while blanket overconfidence adjustments can result in large, unsupportable increases in the frequency estimates, no adjustment results in modest decreases in the mean and 95th percentile estimates. The analysis procedure used confidence intervals for the aggregated estimates as a measure of panel diversity to reflect variability in the individual estimates. An alternative approach used quartiles of the individual estimates, leading to comparable but narrower intervals.

Finally, the largest sensitivity is to the method used to aggregate the individual panelist estimates to obtain group estimates. The analysis procedure used the geometric mean. Arithmetic mean or mixture distribution aggregation can lead to significantly higher mean and 95th percentile estimates. The NUREG states that the analysis procedure develops consensus-type results which are designed to best represent the panel's state of knowledge regarding LOCA frequencies for the stated study objectives.

The NUREG states that the mixture distribution method does not represent a consensus-type group estimate; rather, it is based on the fundamental assumptions that the panel is a random sample from the population of all experts and that the goal is to obtain an unbiased estimate of the aggregate distribution function of LOCA frequency averaged over the population of all experts. The NUREG states that while chosen to be broadly representative of the international community, the selected panel of 12 panelists is not a random sample from this community, and that consequently, there is no basis for extrapolating the study results to the population of all experts.

- **NUREG-XXXX, "Seismic Considerations for the Transition Break Size"**

LOCA frequencies (i.e., the estimated frequencies of pipe rupture as a function of pipe size) are used in a variety of regulatory applications, including PRAs. Currently, the NRC is using such information to develop a risk-informed alternative to the ECCS requirements in 10 CFR 50.46. Current requirements consider pipe breaks in the reactor coolant pressure boundary, up to and including breaks equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system.

To provide the technical basis for a risk-informed alternative, the NRC staff developed LOCA frequency estimates using an expert elicitation process. This process consolidated service history data and insights from probabilistic fracture mechanics studies with knowledge of plant design, operation, and material performance. This elicitation process is well-recognized for quantifying phenomenological knowledge when modeling approaches or data are insufficient. This elicitation focused on determining event frequencies that initiate by unisolable primary side failures that can be exacerbated by material degradation with age under normal operating conditions.

On the basis of the expert elicitation, the NRC staff established a baseline break size corresponding to a break frequency of once per 100,000 years (i.e., 10-5 per year). The staff then adjusted this baseline break size to account for other significant contributing factors that were not explicitly addressed in the expert elicitation to define an alternative risk-informed break size, termed transition break size (TBS). In addition, because the elicitation did not include effects of rare event loadings, such as seismic events, a separate study was undertaken to assess potential seismic effects on the postulated TBS. This report describes the results of this study.

Ideally, to make this study directly comparable with the elicitation, it would be desirable to produce results of this study in terms of the conditional probabilities of break sizes for piping of various diameters, given the occurrence of postulated seismic events associated with different frequencies (i.e., once per 1,000 years, once per 10,000 years, etc.). However, for this study, the staff adopted a hybrid deterministic and probabilistic approach to evaluate flawed and unflawed piping, and indirect failures of other components or component supports that could lead to piping failure. In particular, the study for flawed piping was directed to address the question of what the critical flaw sizes would be in the large piping systems associated with stresses resulting from seismic loads with a frequency of occurrence of 10-5 per year and 10-6 per year. This question focuses on the extent of degradation that would have to be present in a piping system to affect the TBS.

The results of this study indicate that the critical flaws associated with the stresses induced by seismic events with an annual probability of exceedance of 10-5 and 10-6 are generally large and, coupled with other mitigative aspects, the probabilities of pipe breaks larger than the TBS are likely to be less than 10-5 per year.

Inclusion in a PRA of the passive components that are subject to time-dependent degradation and accidental loads presents significant challenges and requires in-depth understanding and data related to the degradation mechanisms and failure modes. The approach used in this study could serve to determine the extent at which degradation of a component becomes risk-significant, and whether such degradation can be managed so that the component failure probabilities remain low.

ATTENDEES

ACRS Members

George Apostolakis, Subcommittee Chairman
Mario Bonaco, Member
Dennis Bley, Member
William Shack, ACRS Chairman
Otto Maynard, Member
John Stetkar, Member

ACRS Staff

G. Shukla, Designated Federal Official

Principal NRC Speakers

R. Dudley, NRR
R. Tregoning, RES
L. Abramson, RES
N. Chokshi, NRO

Other NRC staff and members of the public attended this meeting. A complete list of attendees is in the ACRS office file and is available upon request. The presentation slides and handouts used during the meeting are attached to the office copy of these minutes.

OPENING REMARKS BY CHAIRMAN APOSTOLAKIS

Dr. George E. Apostolakis, Chairman of the ACRS Subcommittee on Digital I&C Systems, convened the meeting at 8:30 a.m. Chairman Apostolakis stated that the purpose of this meeting was to discuss the NUREG-1829 on estimating LOCA frequencies through the elicitation process, and a NUREG Report on seismic considerations for the transition break size. He stated that the subcommittee would hear presentations from the NRC staff. He said the subcommittee would gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, for deliberation by the full ACRS. The rules for participation in the meeting appeared as part of the notice of the meeting published in the *Federal Register* on October 29, 2007. Chairman Apostolakis acknowledged that the Committee had received no written statements or requests for time to make oral statements from members of the public.

DISCUSSION OF AGENDA ITEMS

Presentation on Current Status of 10 CFR 50.46 Rulemaking

Mr. Richard Dudley of the NRR Staff, made a brief presentation on the current status of 10 CFR 50.46 final rulemaking. He stated that the November 16, 2006 ACRS letter recommended several changes before issuing the final rule. The Staff reviewed ACRS recommendations and requested the Commission guidance via SECY-07-082 which provided the Commission with staff recommendation about incorporating ACRS comments into the rulemaking to make Risk-Informed Changes to Loss-of-Coolant Accident Technical Requirements; 10 CFR 50.46a, "Alternative Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactor." In response, the Commission issued a SRM dated August 10, 2007, agreeing with staff on reduced rule priority, agreeing with ACRS to increase defense-in-depth, and let staff decide how to increase defense-in-depth. It also required the Staff to provide rule schedule to Commission by March 31, 2008.

Mr. Dudley further stated that the Commission has agreed with the staff recommendation that it was not a high priority rule and the priority of this rule should be reduced. Chairman Apostolakis asked that what it meant by reducing priority. Does it mean that smaller number of people working on it? Messrs Dudley and Tim Collins replied that it means that because of the limited rulemaking resources, this rule is given a medium priority and will be done after other high priority rulemakings such as 10 CFR 50.46a and 10 CFR 50.46b.

Presentation on NUREG-1829, "Estimating Loss-of-Coolant Accident (LOCA) Frequencies Through The Elicitation Process"

Messrs Robert Tregoning, Lee Abramson of the RES staff, and Mr. Paul Scott of Battelle Labs made a presentation on the passive system LOCA frequencies for risk-informed revision of 10 CFR 50.46. The presentation addressed the following:

A formal elicitation process was used to estimate generic BWR and PWR passive-system LOCA frequencies associated with material degradation. The piping and non-piping base cases were developed and evaluated for anchoring elicitation responses. The panelists provided quantitative estimates supported by qualitative rationale in individual elicitation for underlying technical issues. There was generally a good agreement on qualitative LOCA contributing factors, and there was a large amount of individual uncertainty and panel variability in quantitative estimates. Group results were determined by aggregating individual panelists' estimates. The geometric mean aggregated results are consistent with elicitation objectives and the results are generally comparable with NUREG/CR-5750 estimates. The LOCA frequency estimates are sensitive to the method used to analyze panelists' input, and alternative aggregation schemes can result in higher LOCA frequencies. Overall NUREG-1829 provides a sufficient technical basis to support risk-informing 10 CFR 50.46.

The staff further stated that the motivation for LOCA frequency reevaluation was to develop part of the technical basis for developing alternative design basis break size for use in risk-informing 10 CFR 50.46, and to determine LOCA frequency distributions for plant PRA modeling. The LOCA frequencies were previously developed from operating history. Some notable previous evaluations are: WASH-1400 (1975) estimated frequencies largely based on experience in other industries; NUREG-1150 (1987) updated the WASH-1400 distributions to account for the additional service; NUREG/CR-5750, Appendix J (1998) updated original WASH-1400 study for SB LOCAs while MB and LB LOCA frequencies were calculated from precursor leaks in class 1 systems; and Barsebäck-1 Study (1998) determined estimates using piping reliability attribute and influence characteristics for each degradation mechanism. However, operating history, by itself, may not accurately reflect future performance and requires significant extrapolation for MB and LB LOCA frequencies.

The scope and objectives for reevaluation of LOCA Frequency were to develop piping and non-piping passive system LOCA frequencies as a function of leak rate and operating time up to the end of the license extension period using expert elicitation, including LOCAs which initiate in unisolable portion of reactor coolant system and
LOCAs related to passive component aging, tempered by mitigation measures. Other objective was to determine LOCA frequency distributions for typical plant operational cycle and history, assuming that no significant changes will occur in future plant operating profiles. The expert elicitation process used is a formal process for providing quantitative estimates for the frequency of physical phenomena when the required data is sparse and when the subject is too complex to accurately model. The elicitation process has been used at NRC previously for the development of seismic hazard curves, performance assessments for high-level radioactive waste repository, and for determination of reactor pressure vessel flaw distributions. In this case, the use of the expert elicitation was perfect as based on operating experience LOCA events are rare, and for plant modeling purposes model.

The Elicitation Panel was solicited from the industry, academia, national laboratories, contracting agencies, other government agencies, and international agencies. It was chosen to represent a range of relevant technical specialties. The Facilitation Team was made of normative and substantive experts to provide relevant background knowledge. The LOCA sizes were chosen based on flow rate to group plant system response characteristics. First three categories were similar to NUREG-1150 and NUREG/CR-5750, and three additional LBLOCA categories were used to determine larger break frequencies. Correlations were developed to

relate flow rate to effective break area, and following three time periods were evaluated, current day (average 25 years of operation), end of design life (next 15 years of operation), and end of life extension (following 20 years of operation).

The piping base cases were developed which were available for anchoring the elicitation responses. The base case conditions specified the piping system, piping size, material, loading, degradation mechanism(s), and mitigation procedures. Five base cases were defined. For BWRs, recirculation system (BWR-1) and feedwater system (BWR-2) were selected. For PWRs, hot leg (PWR-1), surge line (PWR-2), and high pressure injection makeup (PWR-3) were selected. The LOCA frequency for each base case condition was calculated as a function of flow rate and operating time. Four panel members individually estimated frequencies, the two using operating experience and other two using probabilistic fracture mechanics.

The non-piping base cases were developed based on the fact that the variety and complexity of the non-piping failure mechanisms makes the piping base case approach intractable. The approach used for development of non-piping base cases was to develop general non-piping precursor database, use PFM modeling to develop LOCA frequencies for targeted degradation mechanisms, such as CRDM ejection, BWR vessel rupture (normal operating and LTOP), and PWR vessel rupture (PTS). The analysis requirements were to choose appropriate base case (non-piping precursor, piping precursor, piping base case, or non-piping base case), and determine relative likelihood of each non-piping failure scenario compared to chosen base case.

The following are the elicitation insights for BWR & PWR Plants:

For BWR Plants: thermal fatigue, intergranular stress corrosion cracking (IGSCC), mechanical fatigue, flow accelerated corrosion (FAC) were identified as important degradation mechanisms. The increased BWR operating transients (e.g., water hammer) were compared to PWR plants. The BWR community has more experience identifying and mitigating degradation due to IGSCC experience in the early 1980s. Additionally, BWR service experience must be carefully evaluated due to preponderance of pre-mitigation IGSCC precursor events.

For PWR Plants: primary water stress corrosion cracking (PWSCC), thermal fatigue, and mechanical fatigue were identified as important degradation mechanisms. The PWSCC concerns were paramount for the panel because of the near-term frequency increases due to PWSCC, however, frequency decreased after effective mitigation measures were implemented.

The following are the elicitation insights for piping and non-piping systems:

For Piping System: the complete failure of smaller piping is generally more likely than the partial failure of larger piping, and aging may have greatest effect on intermediate-size piping (6 – 14”).

For Non-Piping System: the estimation of non-piping failure frequencies is more challenging than the piping failure. Larger non-piping components (e.g., pressurizer, valve bodies, pump bodies, etc) have bigger design margin compared to piping components, but have decreased inspection quantity and quality. The smaller non-piping components (e.g., steam generator

tubes, CRDM nozzles) are expected to benefit most from improved inspection methods and mitigation programs.

The following are the elicitation insights for the total LOCA frequencies:

For BWRs, decreases in frequencies are gradual with the LOCA size due to the IGSCC concerns, and only non-piping failures contribute to the largest breaks. For PWRs, frequencies of smallest pipe breaks (< 4") are high due to steam generator tube and CRDM concerns, and non-piping frequency contributions are important for the largest LOCA sizes.

Presentation on Public Comments and Revision of NUREG-1829

Messrs Robert Tregoning, Lee Abramson of the RES staff, and Mr. Paul Scott of Battelle Labs made a presentation, addressing public comments and revision of NUREG-1829. They stated that the quality assurance evaluations have confirmed the validity of the calculations made to support NUREG-1829. The public comments identified necessary additions and clarifications to facilitate use of NUREG-1829 results. Although, no comments presented a significant challenge to the appropriateness of the objective, elicitation approach, analysis, or results. However, most passionate controversy remaining is the proper method for aggregating individual estimates to produce group estimates.

The staff further discussed the status of NUREG-1829 since the last presentation to ACRS in March, 2005. They stated that they have conducted final Quality Assurance (QA) verification of results, completed responses to public comments, and updated NUREG-1829 based on public comments and QA verification. The QA evaluation results published in draft NUREG-1829 were developed by the NRC staff. Battelle Labs conducted independent analysis of data using analysis methodology documented in NUREG-1829. A few small errors were identified in the original analysis. The median and mean values differed by 7% or less, and the 5^{th} and 95^{th} percentiles varied by 15% or less. The NRC staff conducted second independent analysis as a final quality assurance check and found that the results are identical to Battelle Labs estimates. The NUREG-1829 results have been revised accordingly.

The following questions were posed in the Federal Register Notice for public comments on NUREG-1829: is the structure of the expert elicitation process appropriate for the stated problem and goals of the study, are the assumptions and methodology of the analysis framework used to process the panel responses appropriate and reasonable, are they consistent with the type of information provided by the expert panel and the goals of the study, is the geometric mean aggregation methodology appropriate for the panel responses and the study goals, and should other aggregation methodologies be considered and what are their advantages and disadvantages.

The NRC staff responded to each individual comment, and comments and responses were incorporated into NUREG-1829 as Appendix M. NUREG-1829 was revised in response to selected public comments. The NUREG-1829 was either modified or expanded to clarify principal messages, additional results and comparison of operating experience were added, and additional guidance was provided on the use and interpretation of results.

The significant changes made to the draft NUREG-1829 based on public comments were that it clarified the scope, definition, and interpretation of generic LOCA frequency estimates, clarified safety culture assumptions, provided additional results, and discussed the impact of deficient safety culture at a single plant. It provided precedent for use of median as a group estimate and justification of geometric mean to estimate median, clarified statistical analysis exposition and rank correlation approach, and identified separate steam generator tube rupture and PWR small break LOCA frequencies. It also compared NUREG-1829 estimates to operating experience, and identified results that should replace NUREG/CR-5750 estimates for PRA applications.

Presentation on NUREG-XXXX, "Seismic Considerations for the Transition Break Size"

Messrs Nilesh Chokshi of the NRO staff, and S. Khalid Shaukat of the RES staff made a presentation on the draft NUREG document on seismic considerations for TBS. They stated that NUREG-1829 estimated primary system pipe break frequency from expert elicitation for PWRS, however, it is not feasible to estimate seismic-induced LOCA frequencies that are directly comparable to expert-elicitation results, unless full-scope probabilistic calculations are performed for all applicable degradation mechanisms.

For the TBS NUREG, the objectives were to examine likelihood and conditions that would result in seismically-induced breaks incompatible with the proposed TBS, and to provide key considerations to facilitate the public review and comments. The approach was to use hybrid deterministic and probabilistic approaches with six supporting activities, unflawed piping, flawed piping, indirect failures, review of past earthquake experience, review of past PRAs, and review of a LLNL study conducted in connection with revision to GDC-4. The NUREG-XXX used available design information (e.g., normal operating stresses, seismic stresses, and material properties). Since, such results were only available for PWRs from LBB application database; the evaluations are limited to PWRs. It also used LLNL hazard curves for plants east of Rocky Mountains. It include piping systems with diameter larger than the TBS diameter (e.g., hot leg, cold leg, and cross-over leg), and determined seismic stresses at 10^{-5} (or 10^{-6}) seismic event (elastic stresses) by scaling plant specific SSE stresses. It also applied a correction to 10^{-5} seismic stresses to account for conservatisms in the design process and the extrapolation to higher levels

Key findings for unflawed piping were that the frequency of seismically-induced breaks is much lower than 1E-5/year for the piping systems evaluated. Therefore, the unflawed piping case can be eliminated from further analyses and only flawed piping will need to be evaluated.

For flawed piping surface flaw evaluation, the following four specific analysis procedures were conducted for each of the 52 piping systems: ASME allowable flaw size analysis based on actual strength properties, ASME allowable flaw size analysis based on Code strength properties, critical flaw size analysis for a 10^{-5} annual probability of exceedance seismic event based on actual strength properties, and critical flaw size analysis for a 10^{-6} annual probability of exceedance seismic event based on actual strength properties. Flawed piping analysis were based on fracture criteria that assumes nonlinear behavior, used all stresses pressure, dead-weight, seismic inertial, thermal expansion, and more realistic account for material strengths and toughness values. The following through-wall flaw (LBB) evaluation approach were used:

for standard LBB analysis at SSE stresses with applicable safety factors (SF) on leak rate (SF = 10) and leakage flaw size (SF = 2) and code parameters for critical flaw size analysis; and for 10^{-5} and 10^{-6} seismic loading considered alternate cases with different SFs, but with more realistic accounting for fracture toughness properties.
The following were the key findings for the flawed piping. In most cases, the ASME maximum allowable surface-flaw size at N+SSE loading is smaller than the critical flaw at 10^{-5} or 10^{-6} seismic event loading. The critical crack depths are larger than 40% of thickness for 1E-5 seismic stresses for extremely large circumferential flaws. Similarly, for large circumferential flaws, critical crack depths are larger than 30% of thickness for 1E-6 seismic stresses. The LBB flaw sizes associated with the SSE loading are smaller than the critical mean through-wall flaws at 10^{-5} and 10^{-6} seismic events for most cases with the SFs of 1.5 and 1.0. respectively.

The following approach was used for the Indirect Failures. The failure of support of large components were considered because they may lead to failure of the piping, and LLNL results were used and updated to reflect new hazard and ground motion information.

The following were the key findings of the NUREG on TBS. The frequency of seismically-induced breaks is much lower than 1E-5/year for the unflawed piping systems evaluated. Critical flaws associated with the stresses induced by seismic events of 1E-6 and 1E-5/year are large (crack depths are larger than 30% to 40% of pipe wall thickness), and the probabilities of pipe breaks larger than the TBS are likely to be less than 1E-5/year. Additionally, for two cases analyzed, indirectly induced piping failure (attributable to major component support failure) has a mean failure probability on the order of 1E-6/year.

The draft rule was issued with the discussion of the seismic issue including whether a plant-specific assessments were needed or not. To facilitate feedback, public comments were solicited on the results of the evaluations contained in the report, effects of pipe degradation on seismically-induced LOCA frequencies and the potential affecting the selection of the TBS, and potential approaches and options to address this issue. The following industry comments were received. TBS is not adversely affected by seismic considerations, and the delta risk due to seismic is considered low. EPRI has evaluated sample cases of indirect failure using updated seismic hazard with failure frequency less than 1E-5/yr, and plant-specific assessments should not be required. The staff will evaluate the need for a plant-specific assessment considering the following factors: response to the questions issued with the draft rule, how the rule is revised to address the Commission SRM and the ACRS recommendations, particularly those associated with the defense-in-depth and mitigation, what impact any potential changes under the new rule may have on the seismic risk, and guidance and acceptance criteria to demonstrate applicability of NUREG-1829 results to individual plants.

Closing

Following the staff and industry presentations and discussions, Chairman Apostolakis thanked participants for their contributions and then adjourned the meeting at 4:45 p.m.

SUBCOMMITTEE DECISIONS AND ACTIONS

Overall, the subcommittee was pleased with the staff's progress on both of these NUREG documents. The chairman and the subcommittee members indicated that the staff has done lot

of good work in the subject area and there is a good basis for choosing the transition break size. These documents also provide a good input to the 10 CFR 50.46 rulemaking, and should be issued.

BACKGROUND MATERIALS PROVIDED TO THE SUBCOMMITTEE

1. NUREG-1829, "Estimating Loss-of-Coolant Accident (LOCA) Frequencies Through the Elicitation Process" and associated Appendixes A through M.

2. NUREG-XXXX, "Seismic Considerations for the Transition Break Size"

Note: Additional details can be obtained from the transcript of this meeting available for downloading or viewing on the NRC's public Web site at http://www.nrc.gov/reading-rm/doc-collections/acrs/tr/subcommittee/2007/ or for purchase from Neal R. Gross and Co., Inc. (Court Reporters and Transcribers), 1323 Rhode Island Avenue, NW, Washington, DC 20005; Telephone (202) 234-4433.