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

November 13, 2008

MEMORANDUM TO: ACRS MEMBERS

FROM: Maitri Banerjee, Senior Staff Engineer **/RA/**
Advisory Committee on Reactor Safeguards

SUBJECT: CERTIFICATION OF THE MINUTES OF THE ACRS ESBWR SUBCOMMITTEE MEETING, JUNE 3, 2008- ROCKVILLE, MARYLAND

The minutes of the subject meeting have been certified on November 10, 2008 as the official record of the proceedings for that meeting. A copy of the certified minutes is attached.

Attachment: As stated

cc via e-mail: ACRS Staff Engineers
S. Duraiswamy
J. Flack
H. Nourbakhsh

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MEMORANDUM TO: Maitri Banerjee, Senior Staff Engineer
Reactor Safety Branch A, ACRS

FROM: Michael Corradini, Chairman,
ESBWR Subcommittee

SUBJECT: THE MINUTES OF THE MEETING OF THE SUBCOMMITTEE ON ECONOMIC SIMPLIFIED BOILING WATER REACTOR ON JUNE 3, 2008, IN ROCKVILLE, MARYLAND

I hereby certify, to the best of my knowledge and belief, that the minutes of the subject meeting on June 3, 2008, are an accurate record of the proceedings for that meeting.

/RA/ **November 13, 2008**

Michael Corradini, Chairman Date
ESBWR Subcommittee

CERTIFIED ON: November 13, 2008 ISSUED ON: November 10, 2008
BY: Michael Corradini

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
MINUTES OF THE MEETING OF THE SUBCOMMITTEE ON ECONOMIC
SIMPLIFIED BOILING WATER REACTOR ON JUNE 3, 2008,
IN ROCKVILLE, MARYLAND

On June 3, 2008, the ACRS Subcommittee on Economic Simplified Boiling Water Reactor (ESBWR) held a meeting at the NRC HQ in Rockville, Maryland. The purpose of the meeting was to discuss the design certification (DC) application on ESBWR submitted by General Electric Hitachi Company (GEH) and the results of the staff's review. The meeting was open to the public. The ACRS members and NRC staff who attended the meeting are listed below. The meeting was convened at 8:30 a.m. and adjourned around 6:21 p.m. No written comments or requests to make oral statements were received from the public related to this meeting.

Attendees:

ACRS Members/Staff	**NRC Staff**	**NRC Staff**	**Applicant/Industry**
Michael Corradini (Chairman)	Hossein Hamzehee	Jim Xu	Rick Wachowiak, GEH
William Shack	Mark Caruso	Jeffrey Cruz	Clement Rajendra, GEH
Said Abdel-Khalik	Ed Fuller	Keith Tetter	Gary Miller, GEH
Otto Maynard	Rocky Foster		Ron Thomas, Dominion
Dana Powers	Amy Cubbage		Mike Jonzen, Areva
Jack Sieber	George Thomas		James Ross, GEH
Sam Armijo	Peter Wilson		Mohsen Khatib-Rahbar, ERI
Dennis Bley	Hossein Ismaili		Shilp Vasavada, ERI
John Stetkar	Richard McNally		Roy Karimi, ERI
Mario Bonaca	Mike Snodderly		Lee Dougherty, GEH
George Apostolakis	Sang Rhow		Brandon Shafer, GEH
Harold VanderMolen (DFO)	Thomas Scarbrough		Lou Lanese, GEH/Panlyon Technologies

Note:
DFO=Designated Federal Official

The presentation slides and handouts used during the meeting are attached to the Office Copy of these minutes. The presentations to the Subcommittee are summarized below.

Dr. Michael Corradini, the Chairman of the ESBWR Subcommittee of the ACRS, convened the meeting by stating the purpose of the meeting was to discuss Chapters 19 and 19A of the DC application and corresponding Chapter 22 of the NRC staff's safety evaluation report. Chapter 19 involves probabilistic risk assessment (PRA) and Chapter 19A involves regulatory treatment of non-safety systems (RTNSS).

Mr. Wackowiak of GEH, the DC applicant, started the presentation by describing the revision history of the DC PRA document. The staff had received the latest revision (no. 5), but did not have an opportunity to provide it to the ACRS by the time of the meeting. Mr. Wackowiak noted that the DC PRA provides a bounding assessment to establish a safety case for the ESBWR design certification, and is required to be updated by individual combined license (COL) applicants for a site specific detailed PRA that meets the technical standards in effect one year prior to fuel load. While the COL applications will include only the PRA methodology and results, the site specific PRA will be updated every four years to meet applicable new standards and made available for NRC audit. The members wanted to know how a risk significant change made to a plant component that was not modeled in the PRA before may be captured to ensure the risk worth of all critical components is represented. Mr. Wackowiak explained the process of developing the list of risk significant components by using the failure modes and effects analysis for installed equipment in the plant, the design reliability assurance program (DRAP) and maintenance rule programs, and an expert panel elicitation. The regulatory requirement is that a plant PRA has to reflect the as-built and as operated plant.

Mr. Wackowiak explained the focus of PRA risk improvement at the DC stage is through design choices which will shift to operating /maintenance procedures and practices for the as-built plant to eliminate severe accident vulnerabilities. The ESBWR design manages risk through use of passive systems, and active protection and diverse support systems that minimizing need for human action. The application of the ECCS squib valve, considered a passive system, with its active and diverse support systems was discussed. Considerable discussion ensued regarding control room operators use of active systems which may be non-safety-related, maintenance of reliability of these systems, consideration of adverse system interactions between the active and the passive systems that are credited in the PRA, and desirability of addressing operator action through procedures or design changes. Members expressed concern about potential for adverse interactions between active and passive systems, especially during transition. Mr. Wackowiak stated that a search was made for such adverse interactions followed by design changes to eliminate them.

The process of identifying significant initiating events received considerable interest from the members while the key passive features of the ESBWR were being discussed. The members questioned why the normally open manual valve at the outlet of the GDCS pool is not modeled in the PRA. Mr. Wackowiak explained that the identification of the valve as an important element resulted in design modifications to provide for instrumentation and procedural controls followed by Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) and surveillance testing, thereby improving reliability. It was noted, however, that disk separation failure mode may not be covered in the PRA.

Features of the ESBWR PRA, including systematic search for key modeling uncertainties, documented in the PRA, were discussed. GEH has documented the expert panel review of the PRA models. The open item on PRA quality is expected to be resolved after the staff completes its review of the GEH assessment of the PRA against the ASME-2005 standard. GEH will

provide feedback to the ASME Committee to make the standard more usable for new plants versus operating reactors.

Presentation of the core damage frequency (CDF) risk profile resulted in discussion on best estimate (point value) versus bounding assessment (mean value), seismic risk assessment, consideration of uncertainties, contribution of various events to the overall risk, insights derived or confirmed while going through the process (e.g., need to control fire barriers during plant outages). The GEH process for PRA evaluation and design development follows a parallel path to ensure risk is kept at an acceptable level. GEH expects the fire risk number to go down because of various design improvements (use of fiber versus conventional cables for cabinet connections and improved plant arrangements).

Historic BWR data, experience and publications, modified for the ESBWR design, are used in the initiating events analysis to select risk significant events. Event trees with front line systems, linked fault tree methodology, success criteria based on thermal-hydraulic calculations using MAAP 4.06 and TRACG codes, and sensitivity analysis to confirm success criteria are all elements of the accident sequence analysis. Selection of success criteria for a worst case accident would determine the minimum number of components, while some success criteria (like accumulation of non-condensable gases) are designed into the systems and confirmed through ITTAC. Consideration of failures at subcomponent levels in the PRA, like that of fuses, and common cause failures in I&C systems, received a considerable discussion.

Mr. Wackowiak explained that at the DC stage, neither the equipment nor procedures are established. As a result, detailed modeling of accident progression representing active and passive systems operation followed by additional failures of active components and operator action is not possible. Hence, this issue of not modeling certain elements is qualitatively addressed often thru adverse system interaction review or thru conservative assumptions (assuming a run time failure to happen at time zero). The staff noted that important assumptions in the PRA are documented as COL action items to ensure adequate control.

Mr. Wackowiak discussed the significant open items in the accident sequence analysis. These involved: comparison of the thermal-hydraulic analyses using MAAP vs. TRACG codes for scenarios where water level drops below top of active fuel; TRACG calculation of clad temperatures in regimes the code is not specifically qualified for; rationale for selection of limiting accident scenarios; and treatment of parameters affecting the thermal-hydraulic uncertainty. Some of these open items have been addressed in an RAI response and included in a revision of the PRA.

Mr. Wackowiak discussed the data analysis method that used the generic operating BWR database with use of engineering judgment and some modifications like passive component failure rates adjusted for long maintenance intervals, increased squib valve failure rates etc. The members asked questions regarding the extent and reliability of some of the database, like that of the squib valves and digital system software. Some members noted the lack of a sound technical database and opined that the failure probability should be treated qualitatively instead of using a specific number.

Member Bley questioned the use of Bayesian update of the new vacuum breaker valve where existing data for valves of different designs are used to establish “prior.” Mr. Wackowiak explained that the purpose of the update was to determine if an active backup should be

provided. The design, however, includes an active backup. The members noted the need for more detailed technical discussions, and the staff stated that more detailed discussions on specific technical areas could be scheduled in the future.

Mr. Wackowiak discussed various elements of the human reliability analysis performed for the ESBWR. Member Bley pointed out that given a very low CDF of 10^{-8} achieved by eliminating risk contributors through design changes, the desirability of accurate modeling of human actions became more important.

Mr. Wackowiak presented the Level 1 results with top 5 of the accident sequences. The members again questioned the adequacy of the consideration of the squib valves with limited database in that they affect most accident sequences (cutsets). Sensitivity and uncertainly analyses performed by GEH received considerable attention of the members. The subcommittee would like to see the squib valve database that led to the reliability quantification.

The level 2 PRA model is based on severe accident phenomena evaluation that uses the risk oriented accident analysis methodology (ROAAM). Mr. Wackowiak discussed the containment performance analysis and development of containment system models that are fully linked. The level 2 results were discussed. Significant open item in the area of Level 2 analysis relates to the vacuum breaker design, ITAAC and emergency procedures in case of failed vacuum breakers (COL action item).

The staff's confirmatory analysis did not identify any significant open items in the area of source terms. Offsite consequences were calculated using MAACS2 code with the use of MAAP to generate source terms. Contributions from dominant scenarios were discussed. The analysis did not assume any protective measures provided by emergency preparedness actions. Sensitivity analyses for types of weather patterns, and population distribution were also done. The discussion turned into considerations that affect iodine release. Members Powers and Consultant Kress pointed out that based on current understanding of PHEBUS results, the treatment of iodine in the MAPP code may not be valid. Member Powers pointed out sources and mechanisms that result in gaseous iodine being re-volatilized. Mr. Wackowiak responded that ITAACs address some of these sources and mechanisms. The staff stated that a future presentation would address a number of open issues in this area.

The meeting restarted after a short lunch break with discussion of uncertainty and sensitivity analyses. The members questioned the GEH method of consideration of uncertainty through a point value analysis followed by sensitivity analyses given the nature of database (e.g., squib valves datebase is considered very limited). The members felt that an uncertainty analysis is likely to be needed now as well as in the future as the PRA is used for other purposes. The thermal-hydraulic uncertainty is a significant open item, the resolution of which has both probabilistic and deterministic attributes. The GEH thermal-hydraulic sensitivity results indicate the level of redundancy required to reach the success criteria, with any redundancy allowing for acceptable CDF.

The current fire risk assessment uses NUREG 6850 methods. Lack of fire modeling capability at this stage requires the assumption that the fire develops fully and affects the whole area. Probability of fire propagation to the next area, including propagation of smoke through ventilation and no credit for suppression, was considered. Spurious actuation is considered to be prevented by I&C design, however, in case of a reactor building fire spreading to multiple

processors, an SRV actuation is assumed, regardless, thus failing the most beneficial system, i.e., the ICS. GEH does not believe such an actuation is physically possible, and expects the fire risk to go down even further with as-built fire modeling.

Mr. Wackowiak discussed the conservative assumptions in flood and high wind risk analysis and design changes made to lower the risk. Open items in the area of high wind analysis were mentioned. The members asked if any global warming related projections were addressed and how tornados touching down near but outside the 0.1 square mile plant area were considered.

The seismic margin analysis is based on a limited set of equipment in seismic category 1 structures with a proposed COL action item to confirm capability of buildings and equipment in the as-built plant. The significant open items relate to the spectrum shape used in the margin analysis that is different from the certified seismic design response spectra and modeling of the fault tree for the fire protection water system.

In the area of shutdown and refueling risk, the PRA considered the following conditions: cold shutdown with reactor head on and off; and refueling conditions with reactor level just above the dryer/separators and with the reactor cavity flooded all the way. The other operational modes like startup, hot standby and hot shutdown are considered to be bounded by full power operation risk analysis. No credit is taken for containment while in shutdown. Discussion broke out on the need and possible methods to close the drywell hatch upon a LOCA during shutdown (90% of CDF) (or refueling) in the lower drywell, and design modifications made to reduce the human induced LOCAs. It is possible that after plant procedures are developed, a more accurate quantification of risk may show an increase due to realization of additional failure modes. Mr. Wackowiak also discussed the significant open items in this area of NRC review.

Given that the presentation was running behind schedule, Chairman Corradini proposed to postpone discussion of severe accident management until committee members completed the review of the proprietary BiMAC test report. His intent was to provide members' questions in this area to the staff prior to that presentation.

Mr. Hamzehee from the staff clarified the PRA submittal rules for the DC/COL applicants and COL holders while the staff presented its review of DCD Chapter 19 on PRA. The staff provided a history of review including the RAI responses from GEH and closure of open items with 17 open items still remaining. Demonstration of Commission's objectives and safety goals for certification of design was also discussed.

In the area of quality of the PRA, the staff stated that the treatment of common cause, a major contributor, was adequate. Member Apostolakis asked about the staff's position on the digital I&C common cause failure rate of 10^{-4} given the lack of a sound technical database. The staff responded that regardless of the number, the resulting treatment of this item as a significant contributor was appropriate. The staff needs to determine the best way to address the lack of technical data in the area of I&C system/software failures in the SER.

The staff discussed their review of PRA technical adequacy. Member Bley recommended a future meeting to discuss this area in more detail. He mentioned the fidelity of fault trees and the Bayesian update of the vacuum breaker valve failure rate to be areas of further interest. When staff mentioned the internal "peer" review done by GEH, member Bley suggested that the staff perform a review of the top levels of the fault trees of a few systems before that meeting.

One significant open item in the staff's review deals with the thermal-hydraulic analysis for passive system success criteria. Part of this open item involves use of TRACG for calculating clad temperature, TRACG/MAAP4 comparison for benchmarking the use of MAAP in PRA scenarios, and treatment of parameters affecting thermal-hydraulic uncertainty. Upon member Armijo's question regarding the use of the TRACG code which has been around for quite some time, the staff stated that ESBWR application has some differences in that the core is never uncovered in the design basis analysis, thus requiring justification of adequate modeling by TRACG.

Consultant Kress asked if the staff used MELCOR to audit some of the Level 2 results. The staff responded that MELCOR was used to evaluate a number of scenarios for severe accident behavior and compared with equivalent scenarios analyzed by GEH using the MAAP code.

Chairman Corradini asked the staff to prioritize the 17 remaining open items. In the seismic margin analysis, one major open item was the response spectrum shape resulting from the GE's use of a performance based spectrum different from the certified seismic design response spectra at the low frequency range. The other significant open item deals with the as-built SSCs which should compare favorably with the SSCs assumed in the seismic margin analysis to have high confidence of low probability of failure. This is also a COL action item. The COL holder is required to perform a seismic PRA according to the existing standards and make necessary improvements. Hence, at the DC stage, addressing this item against the Commission's goals may not be feasible.

Member Apostolakis asked if the staff has reviewed the ROAAM process. The staff reviewed the ROAAM report through their review of the Chapter 21 of the PRA that contained it. Regarding the BiMAC test report, the staff has visited the test rig, and expects their review of the report to generate RAIs within a month and a half. Several members pointed out that the BiMAC test must account for the step changes in temperature as well as the heat flux. The concern was that a step change in temperature, if not properly accounted for, could damage the BiMAC.

Mr. Miller of GEH addressed regulatory treatment of non-safety systems (RTNSS) that match risk-significance criteria, i.e., required for addressing the ATWS and station blackout rules, core cooling/containment heat removal/control room habitability/post accident monitoring beyond 72 hours post accident, Commission's safety goal guidelines, containment performance goals, and adverse system interaction. For example, fire protection water system powered by diesels, provides for core and containment cooling beyond 72 hours of accident mitigation. Regarding specific components credited in the PRA (or the focused PRA), the members wanted to know how the assumptions in the PRA are ensured and preserved. There have been interactions between GEH and the staff regarding acceptable quality approaches and methods to control unavailability (TS, availability controls manual, reliability assurance program). There was considerable discussion on adverse system interactions and enhanced/regulatory treatment of the RTNSS.

The staff presentation provided a status of the RAIs, significant technical topics and open items. The ACRS members in their closing statements agreed that in general the PRA developed by GEH appeared to be of adequate quality for meeting the Commission objectives for a design certification. Overall, the members were complementary in the applicant's use of PRA in the design process, and commented that this process should be continued while developing

procedures at the COL stage. However, the Subcommittee has not reviewed the details of the fault trees sufficiently to conclude that some important elements were not omitted. There appeared to be a need to better understand how RTNSS are treated in practical terms. Use of seismic margin analysis in lieu of seismic PRA was another area of interest and future followup. Members felt that given the lack of a meaningful database for digital I&C failures and failure mode insights, use of specific values for failure probabilities in the PRA can not be justified. Use of failure frequencies of various passive safety systems where sufficient database does not exist was a similar concern. Dr. Apostolakis noted a recent EPRI study on this topic and previous NRC research projects to establish bounds on such failure frequencies. The members felt that the subcommittee should review these topics.

The members stated that future subcommittee meetings should also include: a presentation on severe accident management and review staff's confirmatory assessment of severe accident scenarios using MELCOR; the generic issue of boric acid depletion versus xenon build-up in controlling re-criticality; iodine re-volatilization; poisoning of passive autocatalytic hydrogen recombiners, and core degradation with potential re-criticality.

Some members stated that the issue of adverse interactions between active and passive systems, with operators response factored in, may best be reviewed when equipment and operating procedures are developed, but nonetheless, is an issue for further followup. Some members had a concern regarding the containment response with the use of BiMAC in the ESBWR versus bigger spreading area in the ABWR as a mitigation strategy.

The level of detail in the PRA and things that are not considered (maintenance unavailability, spurious closing of normally open valves) in light of the low risk values in the PRA was of concern to member Stetkar who felt that once the design is certified, applicants may not go back to the PRA and update it.

Chairman Corradini addressed scheduling future SC meetings to go over: 1) severe accident management including the BiMAC; 2) selective review of accident analyses regarding the details; 3) fidelity of fault trees to system design descriptions to ensure all possible failure modes concerning the passive systems are captured; 4) some specific issues like, seismic spectrum, physical process for Level 2 PRA and staff's audit using MELCOR code, GEH review of adverse system interaction, and data analysis e.g., for squib valves. GEH stated that they will be prepared to address the TRACG (bounding models not best estimate) vs. MAAP calculations. The members also needed to review the BiMAC results, which were provided to them very recently. After some discussion on future meeting dates, the ESBWR Subcommittee meeting was adjourned at 6:21 pm.