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SUBJECT: PRELIMINARY FEEDBACK ON PBMR WHITE PAPERS

The staff is getting ready to meet with PBMR Pty Ltd on July 18, 2007 to discuss the review so far of the white papers that PBMR has submitted. Four white papers have been submitted on the probabilistic risk assessment approach (ML060950275), the licensing basis events selection (ML061930123), structures, systems and component classification (ML062400070), and defense-in-depth (ML063470549). Staff have provided preliminary feedback comments and questions for PBMR on the first three of the papers. I intend to transmit to PBMR the available results of staff review to enable them to prepare more effectively for the meeting.

Enclosure 1 provides the comments and questions developed so far by the staff. The itemization relates the comments to outcome objectives contained within each white paper in Section 5.

Enclosure 2 provides the list of abbreviations used by the staff.

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MESSAGE	605	07/03/2007 4:33:08 PM
Note w PrlimFdbck Attach.wpd	56062	07/03/2007 4:27:14 PM

Options
Expiration Date: None
Priority: Standard
Reply Requested: No
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Junk Mail Handling Evaluation Results
Message is not eligible for Junk Mail handling
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Junk Mail handling disabled by User
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PRELIMINARY FEEDBACK ON THREE WHITE PAPERS

Please see Enclosure 2 for the definitions of abbreviations.

Development of PRA

1. PRA Approach Paper

   a. Outcome Objective 1: As a matter of technical and regulatory considerations, the staff cannot determine at this point that the scope of the PBMR PRA as described in the WP is appropriate for the intended uses, as further described in follow-on WP.
      i. More detail about how the seismic PRA will be conducted is needed.
      ii. More information about how the fire PRA will be conducted is needed.
      iii. In general, the WP is at too high a level to draw conclusions regarding appropriateness of the PRA for the intended uses.

   b. Outcome Objective 2: The framework for the PRA, at the level described in the WP, appears to be consistent with some aspects of the state-of-the-art for the development of a PRA. However, the staff cannot provide more conclusive comments on the framework until much more detailed information is provided.
      i. A PRA that is used in the design process would look quite different than a PRA performed to examine the risk from an operating plant.

   c. Outcome Objective 3: As a matter of regulatory and policy considerations, the staff cannot determine at this point whether or not the PBMR approaches to initiating event selection, event sequence development, end state definition, and risk metrics are appropriate to support the intended uses of the PRA and to account for the PBMR safety design approach.
      i. As the staff examines the approach that has been described to develop the PBMR PRA, a significant consideration will be how well it addresses operational aspects if it is to be applied toward conforming with regulations such as the maintenance rule (10 CFR Part 50.65) and applied to an oversight process.
      ii. In order to support current risk-informed regulatory applications (e.g., the ROP), there need to be risk metrics that are analogous to CDF and LRF.

   d. Outcome Objective 4: As a matter of technical consideration, the staff cannot determine at this point whether or not the PBMR approach to the treatment of inherent characteristics and passive SSC is reasonable and consistent with the current state-of-the-art of PRA.
      i. There is insufficient information about the reliability characteristics of the passive components, which necessitates the use of expert judgement in the PRA. Since the PRA developed by the approach described is stated to provide major inputs to highly safety significant applications, such as the LBE selection and SSC classification processes, it is not clear that expert judgement can be relied upon to provide an adequate technical basis for regulatory decisionmaking. (Consider, for example, the ongoing efforts to use expert judgement to revise 10 CFR 50.46.)

e. Outcome Objective 5: As a matter of regulatory and policy considerations, the staff cannot determine at this point whether or not the PBMR approaches to the use of deterministic engineering analyses to provide the technical basis for predicting the plant response to initiating events and event sequences, success criteria, and mechanistic source terms yields an appropriate blend of deterministic and probabilistic approaches to support the PBMR design certification.

   i. There is a circular relationship between the PRA and traditional deterministic analyses. Apparently, some limited deterministic analyses will be performed in order to establish key elements of the PRA (e.g., success criteria). Then, the PRA is used to determine the set of LBEs that are examined during the deterministic safety analysis. The applicant needs to provide more details about how deterministic analyses will be used to support the development of the PRA (what codes, how are they verified and validated, etc.).

f. Outcome Objective 6: As a matter of technical consideration, the staff cannot conclude that the approach to the development of a PRA database as outlined in the paper, including the use of applicable data from LWRs, use of expert opinion, and treatment of uncertainty is a reasonable approach for a PBMR PRA.

   i. There is insufficient information about the reliability characteristics of the passive components, which necessitates the use of expert judgement in the PRA. Since the PRA developed by the approach described is stated to provide major inputs to highly safety significant applications, such as the LBE selection and SSC classification processes, it is not clear that expert judgement can be relied upon to provide an adequate technical basis for regulatory decisionmaking. (Consider, for example, the ongoing efforts to use expert judgement to revise 10 CFR 50.46.)

g. Outcome Objective 8: As a matter of regulatory and policy considerations, the staff cannot determine at this point whether or not the PBMR approaches to developing the PRA for the treatment of single and multiple reactor accidents in a multi-module design is sufficient to support certification of the basic single module of the PBMR for multi-module configurations.

h. Outcome Objective 9: As a matter of technical consideration, the staff cannot determine at this point whether or not the PBMR approach to developing the PBMR PRA using current guides and standards for LWR PRA quality and independent peer review, taking into account the differences due to the PBMR's safety design approach, is an acceptable approach to determining adequacy for its intended uses outlined in the WP.

   i. Current standards for PRA quality are not sufficient, as acknowledged by the standards themselves. It is likely that PBMR will need at least to propose additional Supporting Requirements to address the unique aspects of the PBMR PRA, as discussed in Section 3.6 of the ASME PRA Standard.

   ii. PBMR (Pty) Ltd will need to describe the plans for conduct of the peer reviews because of the importance of the peer reviews to the development process. It is not clear to the staff that a suitably independent peer review of the PBMR PRA can be achieved given lack of industry experience with gas-cooled reactors and their PRAs

i. Outcome Objective 10: Although it is stated that the PBMR PRA will be developed to account for uncertainties associated with as-procured, as-built, site-specific, and as-operated information in a conservative and bounding manner to provide assurance that the LBEs derived from the PRA will be appropriate for as-built and as-operated plants, from a technical and regulatory standpoint the staff cannot conclude at this point that the PRA will be adequate to support selection of LBEs for future operating PBMRs.
   i. It is not feasible to agree *a priori* that the PRA produced by the approach described will be adequate to support its stated objectives given that the actual PRA, with its assumptions, models, data, and results, would need to be reviewed.
   ii. There is insufficient information as to how model uncertainties are addressed and folded into an uncertainty distribution.
   iii. There is also insufficient information about the sensitivity analyses that are likely to be needed.

2. LBE Selection Paper

a. Outcome Objective 6: As a matter of regulatory and policy considerations, the staff cannot conclude at this point that a PRA developed such that it examines events to 10^{-8} per plant-year to assure that there are none just below this *de minimus* frequency, and not selecting as LBEs events below 5×10^{-7} per plant-year, is acceptable.

b. Outcome Objective 7: This Outcome Objective characterizes the PBMR PRA as including the kinds of events, failures, and natural phenomena that are: (1) Multiple, dependent, and common cause failures to the extent that these contribute to LBE frequencies; (2) Affect more than one reactor module; (3) Internal events and internal and external plant hazards that occur in all operating and shutdown modes and potentially challenge the capability to satisfactorily retain any licensed source of radioactive material.
   i. It is not clear whether the PRA will include all external events, and whether simplified risk methods (e.g., seismic margins) will be used.

c. Outcome Objective 9: As a matter of technical and regulatory considerations, the staff cannot conclude at this point that the treatment of uncertainty distributions described in this Outcome Objective is acceptable.
   i. The acceptability hinges on issues such as how distributions will be developed to address PRA modeling uncertainties because distributions that only capture the parametric uncertainties are not sufficient.

Application of the PRA

1. PRA Approach Paper

a. Outcome Objective 7: As a matter of technical consideration, the staff cannot determine at this point whether or not the PBMR approach to the application of a

PRA for the objectives of development of a mechanistic source term would be acceptable.

i. The white paper contains insufficient details about key inputs affecting how the mechanistic source terms will actually be computed. For example, the staff would have to review the computational codes that will be used, as well as examine how they have been verified and validated against experimental data.

2. <u>LBE Selection Paper</u>

a. <u>Outcome Objective 1:</u> As a matter of technical consideration, the staff cannot conclude at this point that the process for selecting LBEs using input from the PRA and supported by an integrated blend of deterministic and probabilistic elements is an acceptable approach for defining the PBMR LBEs.

i. The LBE selection process is highly process-driven. A detailed description is need describing how engineering judgement will be used to adjust the set of LBEs developed from the PRA. Will the set of LBEs developed for the PBMR be compared to those developed for other gas-cooled reactors (e.g., Ft. St. Vrain, etc.)? How can it be assured that the proposed LBE selection process produces a robust set of LBEs?

ii. Alternative methods than identifying LBEs based on their occurrence frequencies may need to be explored, such as identifying them according to their risk (the product of frequency and consequence).

iii. The staff would need to ensure that the set of LBEs generated by the proposed approach fully exercises all of the plant features and systems.

b. <u>Outcome Objective 2:</u> As a matter of regulatory and policy considerations, the staff cannot conclude at this point that the integrated blend of deterministic and probabilistic elements described in this WP establishes an appropriate performance-based and risk-informed approach for structuring the safety analyses that will be included in the DCA.

i. The basis for labeling the proposed approach as "performance-based" is not clear.

ii. The acceptance criteria presented as the proposed FC curve (see Section 3.7) is insufficient because engineering-based acceptance criteria (e.g., temperatures, pressures, etc.) are needed to conduct the review.

iii. The staff understands from the WP that the set of LBEs will be identified using simplified methods to estimate accident sequence consequences. These simplifications are needed in order to make the proposed approach practical. However, it is not clear how it is ensured that the results of the more detailed, conservative, deterministic analyses performed on the set of LBEs are consistent with the simplified methods used to identify the set of LBEs.

c. <u>Outcome Objective 3:</u> The statement of this Outcome Objective (that LBEs cover AOOs, DBEs, and BDBEs; that each LBE is defined as a family of individual event sequences where each family has a common initiating event, safety function response, and end state; and that this includes an appropriate definition of LBEs to support the integrated risk from a multi-module plant) is overly broad. Such a statement may be justified, but only if each element is fully substantiated.

d. Outcome Objective 4: As a matter of regulatory and policy considerations, the staff cannot conclude at this point that the limits on the event sequence consequences and the analysis basis for the LBE categories (AOOs, DBEs, BDBEs) as stated in Outcome Objective 4 are acceptable.
   i. Compliance with all applicable regulations is required.
   ii. As currently stated, the erroneous conclusion might be reached that only the DBDEs from a single module need to meet the QHOs.

e. Outcome Objective 5: The statement of this Outcome Objective restates material from the WP that may be justified, but only if each element is fully substantiated.

f. Outcome Objective 8: As a matter of regulatory and policy considerations, the staff cannot reach a conclusion at this point that it is acceptable for the deterministic DBAs for Chapter 15 of Tier 2 of the DCD to be derived from the DBEs by assuming that only SSCs classified as safety-related are available to mitigate the consequences. The Outcome Objective further states that the consequences of deterministic DBAs are based on mechanistic source terms and are conservatively calculated; and that the upper bound consequence of each deterministic DBA must meet the 10 CFR §50.34 consequence limit at the EAB.
   i. More information is needed on use of importance measures in SSC classification.

3. SSC Classification Paper:

a. Outcome Objective 1: As a matter of regulatory and policy considerations, the staff cannot reach a conclusion at this point that the PBMR risk-informed, performance-based approach to safety classification and special treatment that blends the strengths of probabilistic and deterministic methods is acceptable.
   i. It is not clear whether and how 10 CFR 50.69, which SECY-04-0109 states cannot be applied to design certifications, can be used for PBMR.
   ii. In the PBMR methodology, SSCs are classified based on the LBEs which, in turn, are derived from the PRA. The PRA purports to address all sources of radioactive material, including sources in the reactor core and PCS, process systems, and the FHSS. However, it appears that the process systems and FHSS are not considered (e.g., all of the LBEs listed in Table 2 and all of the SSCs listed in Table 5 pertain to the reactor core and PCS). Further, the PRA is based on the conventional initiator-sequence model, which does not address risks arising from routine operations. So, the proposed approach does not consider a complete list of SSCs for classification.

b. Outcome Objective 2: As a matter of regulatory and policy considerations, the staff cannot reach a conclusion at this point that the use of three safety classification categories (SR, NSRST, and NSR as described) and the bases for SSC classification in each category are acceptable.

i. It may be acceptable to use three SSC classification categories provided the basis for classification is justified.

ii. 10 CFR 50.2 requires SSCs to be classified as safety related if they are needed to assure RCS integrity, provide the capability to shutdown the reactor, or meet 10 CFR 50.34 dose criteria. PBMR is proposing to use the 50.34 criteria while it is not clear that justification exists for ignoring the other criteria.

c. Outcome Objective 3: As a matter of regulatory and policy considerations, the staff cannot reach a conclusion at this point that the special treatment for the SR category of classification is commensurate with that needed for the SSCs to perform their capability and reliability requirements during DBEs and high consequence BDBEs to meet the 10 CFR §50.34 dose limits.

i. Detailed information from the DCA is likely to be required to perform this review, as opposed to the high level summary of the special treatment requirements in Table 7.

d. Outcome Objective 4: As a matter of regulatory and policy considerations, the staff cannot reach a conclusion at this point that the special treatment for the NSRST category is commensurate with that needed for the SSCs to perform their capability and reliability requirements during AOOs and high consequence DBEs to meet the 10 CFR Part 20 offsite dose limits.

i. Detailed information from the DCA is likely to be required to perform this review, as opposed to the high level summary of the special treatment requirements in Table 7.

LIST OF ABBREVIATIONS AND THEIR DEFINITIONS

Item No.	Abbreviations	Definition
1	AOO	Abnormal operational occurrence
2	ASME	American Society of Mechanical Engineers
3	BDBE	Beyond design basis events
4	CDF	Core damage frequency
5	CFR	Code of Federal Regulations
6	DBA	Design Basis Accident
7	DBE	Design basis event
8	DCA	Design certification application
9	DCD	Design Control Document
10	EAB	Exclusion Area Boundary
11	FC	Frequency-Consequence
12	FHSS	Fuel handling and storage system
13	LBE	Licensing basis event
14	LRF	Large release frequency
15	LWR	Light-water reactor
16	NSR	Non-safety related
17	NSRST	Non-safety related with special treatment
18	PBMR	Pebble Bed Modular Reactor
19	PCS	Primary coolant system
20	PRA	Probabilistic risk assessment
21	QHO	Quantitative health objective
22	ROP	Reactor oversight process
23	SR	Safety-related
24	SSC	Structures, systems and components
25	WP	White paper