



P B M R

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Director, Office of Nuclear Regulatory Research

NRC Project No. 732

**Subject:** Pre-Application Planning for Design Certification of the Pebble Bed Modular Reactor Design

We wish to thank you for the opportunity to meet on November 3, 2004 to discuss the South African Pebble Bed Modular Reactor (PBMR) project status and plans for pursuing a U.S. design certification under 10 CFR Part 52.

As noted in our February 18, 2004 letter, the PBMR project has been declared a national strategic project in South Africa that is going forward. The preliminary plant design has been completed and PBMR (Pty) Ltd is now in the process of completing the final design and undertaking construction of a full scale Demonstration Plant in South Africa, which is scheduled to start in early 2007.

Like all new reactor designs, receipt of design certification is an essential step in the confirmation of the basic safety of the design for eventual U.S. deployment. PBMR is proposing to start a phased series of pre-application discussions with the NRC to assure that the ultimate design certification application is both complete and sound. The first phase would entail planning meetings to confirm the scope, depth and desired outcomes of the pre-application issues to be addressed, establish schedules and protocols for deliverables, and identify resources and budget needs. This first phase is anticipated to run through mid-2005. The second phase, from July 2005 through December 2006, would consist of focused technical exchanges on the agreed-upon list of issues and NRC documented positions on the approach to each issue. This phased approach helps minimize the impact

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on NRC's limited staff resources during the pre-application period. This will also allow PBMR to efficiently complete the design certification application for submittal in early 2007.

Enclosed is a more detailed discussion of the objectives, key issues, and schedule envisioned for the PBMR pre-application effort as described in our November 3, 2004, meeting. PBMR (Pty) Ltd requests that the NRC review the enclosed materials and establish a proposed date to begin the detailed planning engagement for the PBMR design certification pre-application work.

Please contact me at your convenience by email at: [edward.wallace@pbmr.co.za](mailto:edward.wallace@pbmr.co.za) to further these discussions.

Yours sincerely,



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Enclosure

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Enclosure

## PBMR Design Certification Pre-application Objectives and Schedule

PBMR (Pty) Ltd has underway extensive efforts directed towards finalization of the design, construction and operation of a full scale Pebble Bed Modular Reactor (PBMR) Demonstration Plant in South Africa and submittal of an application under 10 CFR Part 52 for certification of the PBMR design in the U.S. To ensure that the design certification application is complete and high quality, PBMR (Pty) Ltd proposes to enter into pre-application discussions with the NRC beginning in January 2005.

The objectives of the pre-application effort would be to:

- Completely clarify **key issues** unique to the PBMR design certification application,
- Identify any further **development and testing** required for PBMR certification in the U.S., and
- Identify early on any **policy issues** requiring Commission consideration.

### Key Issues

In a letter dated July 22, 2002, Exelon summarized its PBMR pre-application activities with the NRC. The referenced Exelon white papers, NRC requests for additional information, and related correspondence establish a strong basis from which PBMR (Pty) Ltd proposes to begin pre-application discussions. As many of the key issues pursued in the Exelon effort are not relevant to a design certification, PBMR (Pty) Ltd believes that a reduced list of key issues is appropriate for this pre-application effort. The objective would not be to achieve complete resolution of each issue but to arrive at mutual understandings on acceptable paths that would then lead to final resolution of the issues during NRC's review of the design certification application.

Key issues unique to the PBMR design certification effort include:

- **LBE selection methodology and analysis assumptions.** The definition and selection of licensing basis events is fundamental in safety analysis. Modern techniques, including the role of probabilistic risk analysis insights, provide a broader base of plant understanding for safety analysis purposes when coupled with traditional deterministic methods. The methods and assumptions used by PBMR require pre-application discussion in order to effectively prepare a design certification submittal that describes the LBE's for PBMR and how they meet the performance requirements of NRC regulations.
  - **SSC classification / defense-in-depth.** This is interrelated with LBE selection topics. The classification of structures, systems and components stems from the role of each in preventing or mitigating licensing basis events. How defense in depth is factored into the design and the treatment of inherent and passive capabilities are
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different than traditional LWR conditions and require clarification of the requirements for advanced gas reactors.

- **Fuel design and qualification.** A fundamental aspect of the PBMR application is the robustness of the PBMR TRISO coated particle fuel. The production of high quality fuel is essential for ensuring the retention of fission products during both normal operating and potential accident conditions. A set of well-defined manufacturing process and quality controls is critical to the consistent production of high quality fuel.
- **Applicable codes and standards and materials selection.** NRC requests for information on PBMR design codes and standards and high temperature materials performance remained outstanding when Exelon terminated its pre-application review and provide a basis for resuming discussions.
- **Analytical codes and V&V methodology.** Analytical tools would be used to assess the PBMR plant responses to accident conditions. These tools and plans for validation would need to be reviewed by the NRC. Some of the tools developed by German and South African designers may be unfamiliar to the NRC; therefore, early NRC review would be required to ensure an efficient application review. This topic also has significant bearing on the adequacy of the PBMR Development and Testing Program discussed below.
- **Single module vs. multi-module certification.** The modular approach to the PBMR design allows for the placement of one, two, four, or more modules as an integrated plant within a contiguous structure at a single site. How to encompass these variations of the basic module design within the context of a Part 52 design certification is the objective of this issue. The basic safety case should be encompassed on a module basis with appropriate requirements to ensure that there are no interfaces or feedbacks that could invalidate the safety of the plant.

Other issues, related to advanced reactors in general, are being addressed through joint NRC and industry initiatives. PBMR (Pty) Ltd is an active participant in these generic efforts and will continue to seek synergies in their regulatory approaches with those of the PBMR unique issues listed above.

Several prime examples of advanced reactor generic issues are:

- **Development of a technology neutral, risk-informed and performance-based licensing framework.** The hierarchical licensing framework being developed within this program has as its basis the application of the Commission's policy on safety goals to non-LWR designs. Objectives include the clarification of the defense-in-depth principle (the development of containment functional requirements is of keen interest to the PBMR program) and the development of guidance on the use of probabilistic (risk-informed) approaches to advanced reactors licensing.
  - **Development of guidelines on PRA quality and application.** While the focus of this effort is on using a phased approach to develop improved guidance for using risk methods for LWRs, the underlying direction and goals will have applicability to future non-LWR applicants. A Probabilistic Risk Assessment is a required part of a design certification application. The availability of clear guidance on PRA quality and application is, therefore, relevant to a PBMR application.
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- **International regulatory cooperation in design certification reviews.** This relatively new topic involves the pursuit of efficiencies in conducting safety reviews of new reactor designs across international borders. In his recent speech at the 2004 Nuclear Safety Research Conference, Chairman Diaz noted: "For future design certification efforts, the NRC would encourage international participation by other regulators, in both the technical reviews and the related research efforts that support the certification, at the front end."

## Development and Testing

The PBMR development and test program is an essential component of the U.S. design certification effort. Beginning with the extensive technology transfer of the prior German designs and operating experience, PBMR (Pty) Ltd has undertaken a comprehensive program to confirm that all of the PBMR engineering parameters are thoroughly demonstrated. The PBMR development and test program is a very substantial, on-going international effort committed to the future of gas reactors. The elements of the program include:

- **Basic development testing.** Partial and full scale testing of systems and components for PBMR conditions have been conducted to confirm the design approach. Examples include tests to demonstrate the proper operations of the pebble fuel handling systems and components, high temperature control rod drive shock tests under scram conditions, and valve tests to confirm proper operation in a high temperature helium environment.
- **Component development testing.** Full scale testing of components to confirm performance, reliability and maintenance capabilities will be conducted in a new Helium Test Facility. The capabilities of this facility permit testing in helium environments up to 1100°C. The detailed design for this facility has been completed and procurement and construction efforts are now underway.
- **Validation testing programs.** Partial scale tests to validate design assumptions and safety codes are being evaluated. Tests are underway at the German NACOK facility to investigate the oxidation (corrosion) of hot graphite cores by oxygen under natural circulation following an air ingress event. The first two tests in a series of three have been successfully completed and the third test is scheduled for the end of 2004. Additionally, a new approximately 1/6 scale Heat Transfer Test Facility will be used to determine the heat transfer properties of packed graphite pebble beds with heat generation under various cooling conditions. These tests will provide pebble bed heat transfer correlations for use in PBMR analyses software and help expand the knowledge and experience base of the phenomena in a pebble bed.

A comprehensive Fuel and Materials Irradiation Test program has been undertaken to add confirmatory data on the performance of PBMR fuel under normal operating and accident conditions. Laboratory development and testing, ongoing now, will be expanded over the next several years to extend the graphite materials knowledge base for long-term performance. The design for a new Pilot Fuel Plant is nearing completion and construction is scheduled to begin in 2005. This production scale facility will be used to verify PBMR manufactured fuel is of requisite quality and performance.

The design of a full scale Demonstration Plant to be built at Koeberg is well underway

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with construction scheduled to begin in 2007 and fuel load targeted for 2010. This Demonstration Plant will be used for integrated plant performance validation and testing and to provide the final confirmation of the plant performance and safety. Preparation of the Safety Analysis Report, based on Regulatory Guide 1.70 format, is progressing and the report is scheduled for submittal to the South African regulatory authority by January 2006. The Demonstration Plant Safety Analysis Report and its supporting documents, combined with the feedback from the South African regulatory review, will greatly benefit the preparation of the Part 52 design certification application for the U.S..

The objective of the pre-application effort would be for the NRC and PBMR (Pty) Ltd to jointly evaluate the PBMR development and test program to ensure it fully meets the demonstration and testing requirements specified for design certification under 10 CFR 52.47(b)(2). The identification of any further proposed development and testing required for PBMR design certification in the U.S. would be the goal of this effort.

### **Policy Issues**

The NRC staff recently provided the Commission a status report on the development of a technology neutral licensing framework for advanced non-LWR designs (SECY 2004-0157, "Status of Staff's Proposed Regulatory Structure for New Plant Licensing and Potentially New Policy Issues"). The PBMR Pty is actively participating in joint NRC and industry efforts seeking to resolve these issues. Indeed, the PBMR design affords an excellent opportunity for "testing" the concepts, options and recommendations that will be presented to the Commission on these policy issues.

Additionally, PBMR Pty, LTD has identified an additional policy issue with regard to how to address differing multi-module configurations under a single 10 CFR Part 52 design certification without repetitious certifications for each potential configuration variation.

### **Proposed Schedule for Pre-application Interactions**

The proposal is to utilize a multiphase approach similar to that undertaken for other design certification pre-applicants.

#### **Phase 1 - Planning**

- Develop scope and resource plans      November 2004 – June 2005

The goal of this phase is to conduct effective resource planning with the NRC Staff to avoid start/stop events by either party. This phased approach helps to minimize the impact on NRC's limited staff resources during FY2005 and the remainder of the pre-application period.

The list of key issues to be considered during the pre-application effort will be confirmed. Review objectives and outcomes for each issue will be established along with the identification of the scope and schedule for submittals (i.e., topical reports, white papers, safety analysis report sections, presentation materials). Any additional NRC Staff issues

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relevant to the pre-application effort will be identified. Finally, resource estimates will be prepared based on the agreed upon scope.

#### Phase 2 – Key Issues

- Conduct focused technical exchanges July 2005 – June 2006
- NRC Staff position papers July 2006 – December 2006
- Complete pre-application efforts December 2006

#### Phase 3 – Design Certification Preparation, Submittal and Review

- Preparation of application January 2006 – December 2006
  - Application submittal 1Q 2007
  - Application review 2Q 2007 – 4Q 2011
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