November 20, 2001

MEMORANDUM TO: Ashok C. Thadani, Director
Office of Nuclear Regulatory Research

FROM: Thomas L. King, Director */RA/*
Division of Safety Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research

SUBJECT: MEETING WITH EXELON GENERATION COMPANY, DEPARTMENT OF ENERGY, AND OTHER INTERESTED STAKEHOLDERS REGARDING THE PEBBLE BED MODULAR REACTOR

On October 25, 2001, the Nuclear Regulatory Commission (NRC) staff met with representatives of Exelon, the Department of Energy (DOE), and other interested stakeholders to discuss the Pebble Bed Modular Reactor (PBMR) preapplication review efforts. This meeting was one of several meetings conducted between the NRC staff, Exelon, and DOE on technical issues.

Attachment 1 contains the meeting agenda. Attachment 2 contains the attendees. Attachment 3 contains the questions that were asked during each of the four Exelon presentations. Attachment 4 contains the slides used for the presentations.

Stuart Rubin (NRC) opened the meeting by stating that more details than previously discussed would be provided in these presentations. He gave Exelon the opportunity to give an opening statement. Edward Sproat, Vice President, International Projects, Exelon, provided the status of the South African project. No decision has been made on whether to proceed on constructing the South African plant, but the work to design the plant continues. The decision has been delayed at least 6–9 months. The project's budget and plans are still being developed. A main design issue for South Africa is whether the reactor is licensable in the United States. That is to say: How long will it take to get a license? And, what will it take to get a license?

Thomas King (NRC) stated that the NRC is still proceeding on a schedule for providing to the Commission in April 2002 a summary describing the safety issues and their potential resolution. This schedule was based on Exelon's original schedule and plans for proceeding with the preapplication activities. Upon hearing the status and the delay, Thomas King responded that the NRC requests Exelon to formally provide notification of the schedule delay and its implications for Exelon's desired preapplication activities. In addition, Exelon needs to respond to the NRC letter dated September 26, 2001, requesting information on major technical issues. Kevin Borton (Exelon) responded that the answers will be provided by mid-November. He stated that some issues can be covered by the end of the year, the rest by next year. Kevin Borton stated that Exelon can basically answer all the questions, it is just a matter of detail.

Exelon gave four presentations that are summarized as follows: (The questions asked in each of the sessions are found in Attachment 3 and the presentation slides are in Attachment 4).

Pebble Bed Modular Reactor (PBMR) High Temperature Materials Graphite

Mark Davies (PBMR) led this presentation. He highlighted the safety issues related to the use of graphite technology in high temperature reactors and identified the options that could lead to the successful resolution of these issues. PBMR functional and assessment criteria were covered as they relate to the components that will be encountering high temperatures and radiation. Exelon discussed the graphite material including the manufacturing, material properties, performance assessment, and risk mitigation.

The PBMR core structure safety functions include maintaining the pebble bed geometry, ensuring adequate cooling under normal and abnormal conditions, providing access for the reactivity control and shutdown system, and maintaining the de-fueling path. The performance assessment criteria addresses the build up of stresses exceeding the structural limits, the distortion of the reflector columns, and graphite material exhaustion.

PBMR High Temperature (Other) Materials

Mark Davies (PBMR) led this presentation. He covered the other materials that will be encountering high temperatures and radiation. These components include the core barrel, control rods, and the carbon-carbon composites. The presentation covered the standards that the materials will meet, the testing conducted, and analyses performed by the Germans on some of these materials.

Control of Chemical Attack in the PBMR

Albert Koster (Exelon) led this presentation. He discussed the PBMR safety design approach to control of chemical attack. The presentation reviewed the two graphite fire severe accidents. The cause of the Windscale event and the Chernobyl event were summarized. The major factors causing the accidents were compared to the PBMR design. The features of the PBMR design were identified that would prevent such accidents. Further comparisons were made for the PBMR compared to the AVR design and Fort St. Vrain design to resist water ingress.

The PBMR safety design approach is to prevent water corrosion of graphite by limiting pressurized water sources and supply, prevent air corrosion of graphite by providing reliable reactor isolation and limiting air supply, assure core heat removal and control of heat generation, and retain radionuclides in SiC coated fuel particles that are highly temperature and corrosion resistant.

Air ingress is the most serious of the chemical attacks. However, Exelon considers such events as not expected within the lifetime of the plant. The presentation went through the postulated breaks and the design features that would mitigate the event. Some air oxidation tests have been performed and were described.

PBMR Systems Design Approach and Status

This presentation was led Vijay Nilekani (Exelon). The presentation described the overall PBMR design phases. He also provided the status of the different design phases.

The conceptual design that provided the proof of concept was completed in spring 2001. The basic design to provide technical and commercial feasibility data to investors and other stakeholders is currently being completed. The next design phase is the detail design that will provide a detailed and constructible design.

PBMR has a total of 35 systems that are divided into 11 categories, such as the Reactor Pressure Vessel, Electrical/I&C, Plant Support, etc. The design will be for 35 years of full power operation. It was stated that the system design is the outcome of a comprehensive, consistent, and rigorous process. The design principles, processes, and considerations are similar to other nuclear design projects.

In order to illustrate the design documentation structure, he picked the Fuel Handling & Storage System as a representative system. The documentation layout and the information that would be contained in each area were described. The documentation for this system is contained in 10 volumes. It was pointed out that the detailed documentation is proprietary and is not being provided as part of the preapplication submittals.

Closing Comments

Exelon will provide the kind of information wanted. Exelon believes these types of presentations will establish the format and detail for future presentations.

The next meeting is scheduled for November 29 and 30. The agenda for the next meeting is not yet finalized. However, at the next meeting, NRC will discuss the Future Licensing and Inspection Readiness Assessment Report.

Attachments: As stated

cc w/o atts.: See attached list

PBMR Systems Design Approach and Status

This presentation was led Vijay Nilekani (Exelon). The presentation described the overall PBMR Design Phases. He also provided the status of the different design stages. In order to illustrate the design documentation structure, he picked the Fuel Handling & Storage System as a representative system. Vijay described the documentation layout and the information that would be contained in each area. The documentation for this system is contained in 10 volumes. The documentation and P&IDs for this sample system are available for NRC to study, but the documentation will not be formally submitted to NRC. It was pointed out that the documentation is proprietary and not available to the public.

The conceptual design that provided the proof of concept was completed in spring 2001. The basic design to provide technical and commercial feasibility data to investors and other stakeholders is currently being completed. The next design phase is the detail design that will provide a detailed and constructible design.

PBMR has a total of 35 systems that are divided into 11 categories, such as the Reactor Pressure Vessel, Electrical/I&C, Plant Support, etc. The design will be for 35 years of operation. It was stated that the system design is the outcome of a comprehensive, consistent, and rigorous process. The design principles, processes, and considerations are similar to other nuclear design projects.

Closing Comments

Exelon wants NRC feedback on the presentations. Later, Exelon will provide the kind of information wanted. Exelon believes these types of presentations will establish the format and detail for future presentations. Exelon wants to set up a meeting to discuss only schedule. The next technical meeting also needs to be scheduled and agenda prepared.

NRC intends to start the review activities of the PBMR design. The specific areas of review and the NRC staff to perform this review have already been established. The next meeting is scheduled for November 29 and 30. The agenda for the next meeting needs to be finalized. At the next meeting, NRC will discuss the Future Licensing and Inspection Readiness Assessment Report.

Attachments: As stated

cc w/o atts.: See attached list
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Memorandum dated: November 20, 2001

SUBJECT: MEETING WITH EXELON GENERATION COMPANY, DEPARTMENT OF ENERGY, AND OTHER INTERESTED STAKEHOLDERS REGARDING THE PEBBLE BED MODULAR REACTOR

cc w/o atts:

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SUBJECT: MEETING WITH EXELON GENERATION COMPANY, DEPARTMENT OF ENERGY, AND OTHER INTERESTED STAKEHOLDERS REGARDING THE PEBBLE BED MODULAR REACTOR

cc w/o atts (continued):

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AGENDA

NRC Meeting with Exelon and DOE on the PBMR
October 25, 2001, 9:00 a.m. - 3:30 p.m.
ASLBP Hearing Room T3B45

9:00–9:15 a.m.	Introductory Remarks (S. Rubin)	NRC
9:15–11:15	In-Reactor High-Temperature Materials Graphite Structures (Mark Davies)	PBMR
11:15–11:30	Break	
11:30–12:00	In-Reactor High-Temperature Components (Mark Davies)	PBMR
12:00–12:15p.m.	Stakeholder Comments	
12:15-1:15	Lunch	
1:15-2:30	Approach to the Control of Graphite Oxidation (Albert Koster)	PBMR
2:30- 2:45	Break	
2:45-3:15	PBMR System Design Approach and Design Status (Vijay Nilekani)	Exelon
3:15-3:25	Stakeholder Comments	
3:25-3:30	Closing Comments and Adjourn	NRC/Exelon

Attachment 1

Attendance List
NRC/EXELON MEETING
10/25/01

NAME	ORGANIZATION		
Steven Arndt	NRC/RES	301 415-6502	saa@nrc.gov
Joe Muscara	NRC/RES	301 415-5844	jxm@nrc.gov
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Attachment 2

Attendance List
NRC/EXELON MEETING
10/25/01

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Tom King	NRC/RES	301 415-7499	tlk@nrc.gov
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Vijay M. Nilekani	Exelon	610 765-5714	vijay.nilekani@exeloncorp.com

Questions

Pebble Bed Modular Reactor (PBMR) High Temperature Materials Graphite

NRC Staff Question: Will the graphite structure be inspectable?
Exelon Response: Yes

NRC Staff Question: Will the loading on the graphite structure be covered?
Exelon Response: Yes

NRC Staff Question: What is graphite material exhaustion?
Exelon Response: Material exhaustion occurs when the graphite will no longer support its structure and disintegrates. Exelon will try to rename this material state to be more descriptive. This is a performance issue.

NRC Staff Question: Was some of the material changed in the lower part of the plenum?
Exelon Response: Yes, the former design of using graphite is now using metallic materials instead. This is a performance issue.

NRC Staff Question: Does the life of the graphite degrade with radiation?
Exelon Response: The life of the graphite is dependent on radiation and the fabrication process. The assumption is that the operating life is 35 years at a temperature of 750 degrees C.

NRC Staff Question: Do you have information on the degradation of the grade 1 and 2 material and the sleeve material?
Exelon Response: Yes, we have the tensile and flexibility properties. The graphite impurities are quite small, and we are looking at the possibilities of mid-life replacement.

NRC Staff Question: What is the VQMB graphite referenced in your Thermal Resistivity Graph, Slide 21?
Exelon Response: This is the same graphite as the medium grade graphite which is the graphite we intend to use.

NRC Staff Question: What are the differences between your presentation and the Exelon primer?
Exelon Response: There are some differences that will be pointed out as we proceed in the presentation. Stuart Rubin stated that Exelon needs to keep the primer up-to-date.

NRC Staff Question: The data that you are showing is only for perpendicular characteristics. Do you also have the information for the horizontal?
Exelon Response: The characteristics are the same for perpendicular as for the horizontal.

NRC Staff Question: What was the number of samples that were radiated for this data?
Exelon Response: Thirty to forty samples were radiated. The samples are very representative of the rest.

NRC Staff Question: Will you have the information on the actual graphite material that you will use?
Exelon Response: We do not intend to test since we will have 15 years before we reach the critical material point. Exelon's position is that the current data is sufficient to support the design. RES stated that such a fact would have to be given as a condition in the license.

NRC Staff Question: What is the most conservative method?
Exelon Response: Exelon plans to use the best approach method as utilized in the United Kingdom.

NRC Staff Question: Is the graphite sleeve material covered by the curves?
Exelon Response: Curves cover a range of materials some of which are similar to the sleeve material.

NRC Staff Question: When will Exelon decide to have a MTR Program for behavior beyond turnaround? Where will you test? What will you test? At what temperature will you test?
Exelon Response: Exelon is still evaluating the MTR program. If Exelon decides to replace the inner reflector, the risk mitigation will go away. The outer reflector and bottom reflector will never reach the turnaround point.

NRC Staff Question: To determine the condition in the reactor, why do you not put sample pebbles in the fuel?
Exelon Response: Exelon is evaluating this.

PBMR High Temperature (Other) Materials

NRC Staff Question: Did you change the material of the core barrel from the original design?
Exelon Response: Yes, the intent is to use 316 stainless steel.

NRC Staff Question: What is the limit on the core barrel now?
Exelon Response: Temperature limit is 816 degrees C.

NRC Staff Question: The Germans prepared draft guideline KTA 3221- Metallic HTR Components that included Incoloy 800H. Do you know how far the guidelines were reviewed before the program was terminated?
Exelon Response: No, Exelon does not know, but we have copies of the draft guidelines.

NRC Staff Question: Are all these materials that we are discussing within the core region? Will any other material encounter high temperatures?
Exelon Response: This presentation discusses only the reactor internals today, the other materials that could encounter high temperatures will be covered in other presentations.

NRC Staff Question: The blocks at the bottom will see a great delta temperature. How are you addressing this delta?

Exelon Response: The blocks will contain holes and slots to allow flow that should help address the high delta temperature. In addition, these blocks will be considered for replacement.

NRC Staff Question: With the delay that you just announced, how will this impact the combined license application and the early site permit application?

Exelon Response: The activities for the early site permit will continue and will not be impacted by the delay. The COL application will occur in about the fourth quarter of 2003?

Control of Chemical Attack in the PBMR

NRC Staff Question: Does this presentation address water and air ingress?

Exelon Response: No, water and air ingress are unlikely events, and besides, there is plenty of time available to mitigate the consequences for this type of ingress.

NRC Staff Question: Is the reactor of air at 800 degrees C an exothermic reaction?

Exelon Response: No, it is an endothermic reaction.

NRC Staff Question: Are there detectors available to measure helium in the core?

Exelon Response: No, this is being evaluated.

NRC Staff Question: What is the maximum combination of air with helium?

Exelon Response: That is a mixture of 40% air and 60% helium.

NRC Staff Question: During one of these air ingress events, what is the highest temperature of the fuel pebble in the center line?

Exelon Response: We do not know because that is beyond the design basis accident.

NRC Staff Question: When you respond to the NRC, is it possible to list the reference of the documents that you take credit for in addressing the issues?

Exelon Response: Yes, we will do that. Keep in mind that some of those references are proprietary and some are dissertations currently going on.

NRC Staff Question: Are you comfortable that you have all the data on graphite to adequately assess oxidation?

Exelon Response: Yes

NRC Staff Question: How does radiation impact oxidation?

Exelon Response: The impact of oxidation is small, and radiation does have the beneficial factor of making graphite stronger.

PBMR Systems Design Approach and Status

NRC Staff Question: Will PRA be part of these volumes of Systems description?

Exelon Response: No, PRA will get it input from these volumes, but the PRA itself will not be included in these System Volumes. However, these volumes will include failure mode and effect analysis.

NRC Staff Question: Are these volumes the PSAR and FSAR?

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Exelon Response: No, the PSAR and FSAR will obtain their information from this design documentation. The actual outline for the FSAR will occur next year.

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