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Pebble Bed Modular Reactor (Pty) Ltd.
Reg. No. 1999/17946/07

3rd Floor, Lake Buena Vista Building 1267 Gordon Hood Avenue Centurion Republic of South Africa
PO Box 9396 Centurion 0046 Tel (+27 12) 677-9400 Fax (+27 12) 663-3052/8797/ 677-9446

Mr. Stuart Rubin
Regulatory Effectiveness Assessment and Human Factors Branch
Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research
Mail Stop: T-10E32
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

| Date: | Your Ref. | Our Ref.: | Enquiries: |
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| 4February 2004 | | | EG Wallace |
| | | | TEL:US 423-344-6774 |

Dear Mr. Rubin:

**Subject:** Comments on NRC January 14, 2004 Advanced Reactors Workshop on Containment

PBMR Pty LTD is pleased to offer the following comments on the subject of containment requirements for advanced reactors, particularly advanced high temperature gas reactors (HTGRs).

The NRC has previously stated in policy and other documents that for advance reactors, particularly non-LWR reactors, the need for a conventional containment, i.e., high pressure, low leakage containment typical to LWR technologies, should not be a foregone conclusion. Rather, there should be flexibility for designers to achieve, with a high level of confidence, public safety by means that do not necessarily include a conventional containment. PBMR Pty, LTD believes that approach is the best way to assure unfettered advancements in reactor design and safety.

HTGR safety is achieved in a fundamentally different way than LWR safety. The PBMR design provides a very high level of protection to the public without a conventional containment. First and foremost, the first barrier to fission product release, the fuel, is fundamentally different than LWR fuel. The fuel in ceramic form cannot melt. The choice of the pebble fuel configuration with TRISO coated uranium oxide particles creates approximately 455,000 independent fuel elements in total containing over six billion separate fuel microspheres, each containing robust, multiple barriers to fission product release. This fundamental design difference eliminates the potential for simultaneous failures of fuel elements and large, rapid fission product releases. The severe accident scenarios associated with LWRs are difficult to conceive for a HTGR.

For the greatest protection of the public, the PBMR design provides for the early venting of helium (primary coolant) released in the event of a primary pressure boundary leak or rupture. Due to the basic nature of the design, the helium released early in any event sequence contains only normal circulating activity and some resuspended dust from the system. This release has minimal consequences to the public. Once the reactor system and building are depressurized, the motive force for any subsequent fission product transport to the environment is removed. Thus, venting the released primary inventory from the building benefits safety. When the pressure in the building drops back to normal, the building can be reclosed and ventilation restored. Furthermore, unlike LWR designs, accident scenarios for HTGR designs are very slow, evolving over several days to reach peak fuel temperatures. Although public health and safety is assured by passive mean, this provides substantial time for effective manual intervention and additional mitigation actions in the accident scenarios, providing defense-in-depth for accident management. For the PBMR design, venting the building of released helium allows subsequent operator entry and enables restoration of equipment, resealing of leaks or other mitigation appropriate to the event before peak elevated fuel temperatures are reached.

Having addressed the primary mechanism for transport of fission products, the issue of whether a substantial source term can be generated must be considered. HTGR designers, particularly for smaller, passive designs like PBMR, have intentionally limited the potential for excessive core temperatures that could lead to significant fission product release in their basic decisions on core power, fuel design, core configuration, excess reactivity, reactor vessel and building designs. By sacrificing ultimate power output, design decisions on core geometry and overall size, excess reactivity and incorporation of strong negative temperature coefficients of the reactor limit heat generation and provide conditions where large heat sinks close coupled to the fuel that can passively remove the decay heat that is generated. Setting operating and accident fuel temperature design limits well within the capabilities of the fuel to retain fission products adds additional margin and confidence in assuring public health and safety. Limiting core temperatures to well within the capabilities of the fuel realistically eliminates the potential for large fission product release source terms and the choice of fuel design realistically eliminates the possibility of severe core damage from a risk-informed perspective. With this design philosophy, confidence in the protection of public health and safety can shift from a heavy weighting on mitigating capabilities to design features that prevent large source terms in the first place.

The NRC initial proposals regarding containment discussed in the January 14th workshop appear to be predicated on two points. First, that there must be defined functional objectives down to a level that contains prescriptions for design similar to current LWR regulations. Second, for defense-in-depth reasons, advanced reactors must still be presumed to have severe accidents scenarios that would benefit from some form of containment structure to mitigate beyond design bases scenarios. Both of these predicates should be abandoned by the NRC.

Designers of advanced reactors should continue to have flexibility in defining how to meet public health and safety objectives. With different design concepts under consideration, the NRC acceptance criteria should be at a high level, characterizing the outcomes to the public that are acceptable rather than on prescriptive design features that may only apply to a particular technology type.

Additionally, the resolution of containment requirements appears premature given the broader NRC initiative to establish a risk-informed, performance-based regulatory framework for advanced reactors. The resolution of containment criteria should be made in the broader context of that new regulatory framework. In the context of a new performance based, risk-informed regulatory structure, the different features of a design to prevent and mitigate fission product release from the fuel, based on mechanistic source terms, may be sufficiently reliable for a given design to require no dependency on a containment building. This in turn provides more flexibility for designers and regulators to evaluate the remaining performance of installed plant SSC as part of the defense in depth of the design, including, among other things, the benefits of a resealed reactor building, under realistic conditions for beyond design basis events.

Should the NRC desire to establish requirements for advanced reactors regarding containment or confinement before the broader framework is developed, the following approach should be considered:

- Establish acceptance criteria for the development of mechanistic source terms for each advanced reactor type.
- Reaffirm the public health and safety goals applicable to advanced reactors so that functional criteria and performance metrics for SSC's can be established utilizing risk-informed insights.
- Make no pre-emptive requirements for containment mitigation features in advanced designs predicated on a severe accident presumption.

With respect to the draft containment performance criteria put forth by the Staff on January 14, 2004, the following comments are offered:

- Avoid presuming that the functions are applicable to a single SSC.
- Combine the first two functional criteria and replace with "Control fission product releases within acceptable limits." The early release of low activity pre-accident circulating helium maintains the building near atmospheric conditions removes the driving force for later additional fission product release and allows environmental conditions within the buildings to be returned to levels acceptable for human entry. Coupled with the long times (greater than 2 days) before peak fuel temperatures are reached without any active cooling, operator actions to seal leaks, restore active cooling and close the building add substantial defense in depth capability. If a low leakage, high pressure containment was utilized, essentially all the equipment in the plant would be exposed to higher temperatures which could induce failure and the reactor building would be too harsh an environment for re-entry and additional mitigating actions.
- The third criteria should read "Provide passive reactor heat removal capacity to maintain fuel within acceptable limits". If the geometry of the reactor and its surrounding structure (citadel in PBMR's case) remain intact, passive cooling is assured. This is not specifically a "containment" function, but it is one function of the reactor building.
- The fourth "Protect safety equipment from natural phenomena and dynamic effects" is a function of the reactor building design whether it is a containment or a vented confinement.
- Other regulatory requirements deal with radiation protection of workers and this should not be the subject of this regulatory initiative.
- The reactor building does provide physical protection for vital equipment. However, other regulatory requirements deal with physical security and should not be a part of this regulatory initiative.

PBMR appreciates the opportunity to contribute to the development of this significant element of advanced reactor regulation. It is important that the dialogue with industry demonstrated in this workshop continue. The issue of containment for advanced reactors is a complex topic that deserves careful consideration and diverse input. PBMR looks forward to the NRC proposed follow-on workshop to hear the evolving Staff views coming from this latest workshop.

Yours sincerely,

E. G. Wallace

Sr. General Manager-US Programs
US Tel: 423-344-6774
US Fax: 423-316-1319

Cc: S. Broude, US NRC RES