From: Yuri Orechwa \> NRR
To: Ralph Caruso
Date: Mon, Mar 25, 2002 2:44 PM
Subject: RAIs

Ralph et al.

Attached are the RAIs on the PBMR white papers - Core Design and Heat transfer.

Comments, additions and/or subtractions are being solicited.

Yuri

CC: Amy Cubbage; Shanlai Lu; Undine Shoop

C/60

RAIs on the PBMR White Paper - Core Design

prepared by NRR/DSSA

1) Pebble flow was evaluated by comparing German experiments and South African computer simulation. It is stated that agreement is within 10 %. What parameters were compared? What is their safety significance?

2) Please justify why the German pebble flow experiments are applicable to PBMR computer simulation assessment. What are the figures of merit? How will the biases and uncertainties be estimated and how will they be ultimately incorporated into the VSOP code prediction of pebble flow?

3) Porosity distribution variations in the pebble bed of up to 10 % have been reported.

a) What is the radial and axial variation in the porosity in the PBMR core?

b) What is the variation in the porosity inward from the wall to two pebble diameters? What effect if any does this have on the estimate of the rod worth?

c) At the wall the porosity goes to unity. Are transport corrections necessary and used at the wall in VSOP to compute rod worth? Is this taken into account in computing the shut down margin?

d) Is the porosity variation taken into account in computing the fuel temperature distribution and its uncertainty?

4) Since the size of the central reflector, and the mixing zone are strongly defined by the manner in which the pebbles are loaded, how do you benchmark the computation?

a) Since one simulation takes ~4 months, parametric studies appear to be limited. So which calculations/simulations are the defining computations?

b) Does the ANNABEK experiment (to which the PEC-3D simulation was compared) contain a central reflector column? Please describe the experiment in detail and its relevance to PEC-3D simulation.

5) What is the correlation between the local pebble flow velocity and the local porosity?

a) In VSOP calculations how are the regions associated with each fixed flow velocity and porosity sized appropriately?

6) Please describe the VSOP validation and verification process. In particular, the experiments used in the validation and the mathematical benchmarks used in the model verification and give the results.

7) The uncertainties of 8 and 5 % used in determining the computed shutdown margin (Table

2.7-1) are based on the "German Practice". What is the German practice and why is it appropriate for the PBMR design?

a) What is the C/E and its uncertainty associated with the PBMR rod worth?

b) Is the ASTRA facility in Russia which will be used to validate the control rod worth calculations sufficiently representative for the task? Are the rods in the reflector? Please explain.

8) It is mentioned that the control rods are chain driven. Please provide additional information on the control rod system, including a detailed description, operational characteristics, and material composition. Please provide similar information for the absorber sphere system. Please provide information regarding the modeling and the methodology for calculation the rod worths.

9) The aspect ratio (3 :1) of the PBMR core is significantly greater than what has been encountered in operating reactors of any type.

a) What is the shape of the 1st harmonic of the flux distribution? Is it degenerate?

b) How is this harmonic affected by a stuck rod?

c) What is the 1st to fundamental mode eigenvalue separation?

d) What role, if any, does the 1st harmonic play in postulated overpower transients and Xe swings?

e) The core axial transit time for a change in the helium mass at the core inlet is much longer than the neutronic effect. Can you preclude stability problems?

10) Provide additional description of the fuel handling block valve system.

11) Describe the validation of the temperature coefficients quoted in Table 2.6-1.

RAIs on the PBMR Whit Paper - Heat Removal

prepared by NRR/DSSA

1. It has been indicated that the power level is controlled through Helium Inventory Control System. If the system has been designed, please provide detailed system descriptions, design limits and operational interactions with the reactor control rod/sphere absorber system and the turbine/generator load control system.

If the system has not been designed, please provide the design criteria, expected system interactions and the considerations regarding the normal Helium inventory loss through the system leaks.

It has been known that maintaining the Helium inventory is a big burden for operating a HTGR. Have any considerations been given to develop a program to monitor, verify and compensate the helium loss through the system leaks during the normal operation?

2. Two turbine/compressor units and a turbine/generator unit will be used according to the current PBMR design. Traditionally, the turbine/compressor system operation characteristics are not the main focus of NRC's interest. However, the operational characteristics of these three turbine systems have significant impact on the reactor side control and response. Therefore, please provide the following design information about these three units:

a). Operational characteristics of these units, e.g., inlet/outlet temperature/pressure versus power
level, rotational speed of the turbine/compressor units versus power.

b). Turbine/compressor bearing and seal design. The duration of the operation could be significantly affected by the performance of this part of the design. The allowable leakage flow rate may also affect the cycle efficiency and the balance of the plant.

c). Turbine rotational speed control system information. Particular for the turbine/generator unit.

3. Please provide detailed design information regarding the reactor core conditioning system. If it has not been designed, please provide all the design criteria and the basis.

4. Code cases are discussed several times in the document. Please provide information on all the code cases used in the PBMR design.

5. How will core bypass flow be determined, validated, and monitored over the the life time of the PBMR?

6. What is the spatial distribution of the temperature coefficients in the PBMR for the initial cycle and the equilibrium cycle. Does the distribution change over the range of expected helium inventory changes? What effect does this have on the maximum fuel temperature during transients of interest to the safety of the PBMR?

7. The quantity of heat removed is regulated by blower speed and bypass valve manipulation.

Can these be varied independently in such a way as to lead to unstable core response?

8. On reactor scram the Brayton cycle collapses by opening the bypass valves. What are the consequences of on or more bypass valve sticking totally of partially shut?

9. It is stated that on load rejection the generator bypass valves prevent over-speeding. How is this achieved? Under what, if any, circumstances is over-speeding possible? What would be the reactivity and consequent temperature effects?

10. It is stated that in an unplanned shutdown within a few minutes the SBS is started for the continues active heat removal. What are the rules with regard to failure to start the SBS and what are the consequencs.

11. During maintenance the RUCS keeps the core at the required temperature. What are the consequences and how are they addressed of a failure of the RUCS during maintenance?

12. What is the assumed bypass flow in the quoted peak fuel temperature calculations? What is the sensitivity of the temperature to this assumption? Is the peak temperature linear in the bypass flow assuymption?