PBMR Response to NRC Questions
From June 13, 2001 Meeting

Note: Proprietary information has been deleted as indicated by blank or ellipsis.

1. How do the fuel packing fractions compare – German vs. RSA?
The PBMR packing is particles per sphere, the same as the German proof test of spheres manufactured and tested in 1988. The packing fraction is well within the envelope of all the fuel the Germans tested successfully, which ranged from particles per sphere to particles per sphere.

2. Do you look for damage to the kernels during the "packing" portion of the fuel manufacturing process?
Yes.
Each uranium dioxide kernel is coated with four layers:
(1) a porous carbon buffer
(2) a pyrolytic carbon layer
(3) a silicon carbide layer and
(4) a final pyrolytic carbon layer.
After coating, they are now referred to as coated particles.
The coated particles … lot.

3. Referencing the graph showing free uranium content in fuel, what drove the improvements for the HTR-10 fuel (Chinese experience)?
As far as we know the Chinese used a similar process to that used in Germany. The improvement after initial batches with higher free uranium fraction is due to a learning process of mainly the pressing step in the manufacturing process. The same is expected to happen with the PBMR process during the production of initial fuel batches.

4. What are the reasons for the differences in the maximum fuel temperatures between PBMR and the Germans Phase I and AVR fuel temperatures?
PBMR will inquire whether any reports on the matter of the unexpected high temperatures encountered in the AVR are available in Germany. (OPEN ITEM)

5. How many pebbles do you load before seeing coolant activity?
Coolant activity is not expected until operation at power is sustained.

6. Will radial variations in coolant temperature be able to be monitored?
PBMR is not planning to place any thermocouples inside the reactor core. PBMR is considering placing thermo-couples and neutron detectors in the demonstration plant's graphite reflectors. This will detect radial (azimuthal) imbalances in power distribution.

7. With regard to pebble flow experiments, how were temperature effects accounted for?
As far as we know no tests were performed with helium at operating temperature. The Germans did perform many flow experiments with spherical balls of different materials having different friction factors. PBMR will review the German records. (OPEN ITEM)

8. Did the Germans ever find higher burn-up levels than predicted by modeling?
During operation, the burnup of each sphere is measured as it is removed from the core, prior to re-insertion. Fuel spheres that would exceed the limit if re-inserted for an additional cycle were permanently discharged. PBMR will inquire whether there was any fuel that exceeded the burnup limit, including fuel that was in the reactor at the time the AVR was shut down. However, fuel has been irradiated to burnups higher than planned for PBMR. (OPEN ITEM)

9. What confidence do you have that pebbles don't actually get "hung up" in the core? Any insights from AVR?
The Germans had some fuel spheres restrained from movement by the graphite reflector. PBMR is reviewing this issue with the Germans although it has a different graphite reflector design based on this experience. (OPEN ITEM)

10. It was noted that the presentation had been focused on German experience. What are the plans for this (PBMR) fuel?
PBMR fuel plans will be presented to NRC on July 18, 2001. (OPEN ITEM)

11. NRC noted the need for Quality and Acceptance Testing details.
In the proprietary session following the public session PBMR presented the fuel product specifications, source of fuel materials and characteristics to be measured for QC checks.

12. Did AVR testing simulate load following (temperature/power transient issue)?
Not that we are currently aware of.

13. NRC questioned the appropriateness of using the Poisson distribution for modeling (failure fraction vs. temperature).
The heading of the slide on page 28 of the presentation on June 13, 2001 was in error. The slide in fact shows results using a binomial distribution and not a Poisson distribution.

14. Referencing page 32 of handout, if the test results are for various fuel batches (rather than for the reference AVR 21-2 fuel), what is the significance of the results?
This slide demonstrates that….

15. Will the burn-up measurement system be digital?

Yes.
The system will measure Cesium-137 activity. Major components of the system are its collimator, Germanium detector and amplifier/signal processor/computer assembly. The burn-up measurement system operates in an automated manner. Controls to the system and measurement results from the system are interfaced to the Fuel Handling and Storage System operational control system via input and output signals. A local operator interface display and keypad panel is provided at the system's electronic enclosure for calibration, troubleshooting and maintenance activities. Testing, validation and proving the equipment performance are planned.

16. What is the asterisk on the anisotropy values?
It refers to the fact that ….

17. How does the drop strength test height (   ) compare with actual drop height?
The actual drop….

18. How does the number of drops in test (   ) compare with expected number of drops in operation?
A fuel sphere is expected to be recycled in the core….

19. What is the source of the corrosion limit   ?
It came from German material graphite standard.

20. On page 17 with regard to these QC checks, were these German tests or will they be the QC checks done for PBMR?
They were the tests done in Germany and will be the QC checks for PBMR.

21. On page 20, are the methods specified new, or the same as the Germans?
The same as the Germans.

22. On page 26, within the test designation numbers, what do K and P mean?
K refers to a sphere, P to a particle.

23. On Page 27, what was method of heat-up?
Heat-up was done via oven testing. Zero failures observed**.**

24. What is definition of failure fraction?
PBMR distinguishes fuel anomalies as:
1. Fuel manufacturing defects as measured by the free uranium fraction which includes tramp uranium (failed particle fraction – the fraction of coated particles that have been damaged in manufacture).
2. Fuel mechanical failures as measured by broken or cracked spheres as a result of drops, handling damage etc.
3. Fuel failures in the reactor is measured by Krypton-85 level in the coolant above the level than can be expected from manufacturing defects.

25. On Page 32, how is a fast neutron defined?
Neutrons with energies greater than 0.1 Mev.

26. NRC noted that it would need to help establish acceptance criteria – Safety Limits, Operating limits, etc.
Another meeting will be planned with the NRC discussing Safety analysis, Design basis accidents, operating limits, etc., at the appropriate time.

27. What are PBMR's nuclear material control and accountability plans?
PBMR has developed a conceptual plan that has been endorsed by IAEA. The issue of material accountability will be addressed at a future meeting. (OPEN ITEM)

28. NRC requested more detail about source term projections, analysis, testing plans, etc. Expected release in terms of time and temperature and the uncertainty related to the release projection.
A separate presentation to the NRC will be made on the radiological effects during steady state, transient and accident conditions at the appropriate time.
(OPEN ITEM)

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