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- copy
- J. Lyons
- J. Wermiel
- Pls make sure that these are covered in review.

Gary 12/11/01

ML020380004

November 12, 2001

~~Frank~~
Yuri

FYI 12/1
I'm not sure what Gary is really trying to say since we're not in the "review" mode as yet.
Jerry W.

Mr. Thomas King
Director, DSARE
Office of Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. King:

This letter is to report my comments on the HTGCR Safety and Research Issues Workshop held by NRC on October 10-12.

There are several inherent positive safety characteristics of HTGCRs that are well known and have been demonstrated in prototype reactors. These include a low core power density, high heat capacity of core and structures, relatively low stored energy in the coolant, large margins to fuel failure and low worker doses during normal operation. Still, there are a significant number of safety research needs documented by Mr. Boyak and Mr. Meyer during the workshop, and I subscribe to those research needs.

There is a design feature of the Pebble Bed Modular Reactor that raises significant safety questions which appear not to have been thoroughly studied. The reactor core is nominally a right circular cylinder and consists of two zones. The inner zone contains approximately 110,000 inert graphite spheres, and the annular outer zone contains approximately 330,000 fuel spheres. The two zones are not separated by a physical barrier and the inert spheres and fuel spheres can intermix. Thus, the internal geometry of the PBMR core cannot be known precisely during operation.

T/36

It is possible that fuel spheres may migrate well into the inner core zone where the neutron density is highest. This would result in a higher power density and higher fuel temperatures for those fuel spheres. The assessment of peak fuel temperatures thus becomes a complicated statistical calculation.

We were told that the nominal packing fraction of the spheres during operation is 0.61 and that the theoretical maximum packing fraction is 0.74. Further, we were told that there was the possibility of "bridging" of the spheres, thereby producing regions of lower packing fraction in the core. It is possible to contemplate, therefore, that a shaking of the reactor vessel and core (from seismic motion, for example) could lead to a sudden increase in core density of 10-20%.

It was noted in the workshop that pebble bed compaction (increase in core density) would increase the core reactivity through reduced neutron leakage. But there is another phenomenon that might be more important than reduced neutron leakage. In an undermoderated core such as PBMR an increase in core density of 10-20% would lead to a softer neutron energy spectrum and a consequent increase in fission rate relative to neutron capture rate. One would have to do careful neutron physics calculations to assess the magnitude of the positive reactivity effects of a core compaction event, but my judgment is that it would be well over a dollar of reactivity. If that proves to be the case, and if as it appears the only significant prompt negative reactivity feedback effect is the Doppler effect from U-238 heatup, the PBMR core and fuel spheres could be subjected to a severe power excursion in a core compaction event.

There are several obvious questions for research that arise from a postulated core compaction event (which does not seem to me to be a highly unlikely event.)

- What is the magnitude of positive reactivity increase due to a 10-20% increase in core density?
- What is the magnitude of the Doppler feedback coefficient?
- Are there other prompt negative feedback effects?
- What is the resultant power excursion from a core compaction event?
- What is the response of individual fuel spheres to the power excursions?
- What is the response of the pebble bed core to the power excursions?

I believe the latter two questions have to be addressed through experiments in a test reactor.

N/A since [illegible]

A related issue that would have to be addressed in the safety review of PBMR is that a seismic event could cause simultaneous power excursions in all the reactors of a multiple module facility. This raises obvious questions of control room staffing as well as consequence calculations.

If you have any questions concerning these comments, please call me at (301)469-7573.

Best regards,

Tom

Thomas E. Murley

Cc: Mr. William Travers, EDO
Mr. Samuel Collins, NRR
Mr. Ashok Thadani, RES
Mr. John Larkins, ACRS