Staff's Comments on
Fuel Performance

During the public portion of the meeting on June 13th, the NRC staff handed out pages 88 and 89 copied from the German report "AVR - 20 Jahre Betrieb" [AVR - 20 Years of Operation] (VDI Berichte 729, VDI Verlag, 1989) (Attachment 5-a). As described below, Attachment 5-a refers to the higher-than-expected maximum coolant temperatures seen in test results from the AVR pebble-bed reactor:

Because a pebble-bed core lacks structures to accommodate traditional in-core instrumentation, maximum coolant temperatures under normal operating conditions in the AVR core were inferred from a melt-wire experiment. In that experiment, hundreds of non-fueled graphite pebbles were equipped with a graphite plug containing twenty encapsulated wires with melting temperatures ranging up to 1280°C. Along with normal fuel-containing pebbles, these so-called monitor pebbles were added to the top of the pebble bed, through either the central loading tube or one of the peripheral loading tube positions, and then removed from the bottom discharge tube after a single pass through the core.

Since the AVR monitor pebbles produced negligible heat (i.e., they contained no fuel), the number of melted wires provided an indication of the maximum helium coolant temperature seen by that pebble. Unexpectedly, a significant number of monitor pebbles (i.e., six loaded in the central core region, sixteen in the peripheral core region) proved to have melted all twenty wires, thus indicating a maximum coolant temperature in excess of 1280°C. These results were with the AVR operating at a nominal coolant outlet temperature of 950°C.

After briefly describing these AVR monitor-pebble results, the staff asked a series of questions to find out to what extent the PBMR design team had considered the implications of the AVR test results when stating that the maximum fuel operating temperature is 1060°C in the PBMR when the nominal coolant outlet temperature is 900°C. Dr. Johan Venter (RSA) responded with the familiar explanation that the AVR results can be attributed to the neutron moderating effects from the graphite "noses" that protruded from the side reflector into outer core region of the AVR and that are absent in the PBMR design. Specifically, as has been previously claimed (e.g., Nuclear Engineering and Design, Volume 121, No. 2, p. 144, July 1990), Dr. Venter indicated that the unexpected hot spots seen in the AVR monitor-pebble results were caused by elevated power production in the fuel pebbles near the graphite noses.

The staff commented that this explanation seems to be inconsistent with the data, since the inner radial core region - far removed from the graphite noses - showed roughly as many hot spots as the outer core region (i.e., more monitor pebbles were loaded into the outer fuel region than the inner). The staff then asked whether the familiar explanation of the AVR monitor-pebble results has been supported by a detailed analysis that quantitatively predicts the observed range of maximum coolant temperatures in the AVR and whether the prediction of the maximum fuel operating temperature in the PBMR has been based on similarly detailed analysis. Dr. Venter said he did not know the particular details of the thermal analyses for the AVR test results and the PBMR design but that he would look into them and have detailed answers provided at a future meeting. The staff expects to further pursue the issue of maximum fuel operating temperatures in relation to the fuel testing program and the integral testing planned for the demonstration module in South Africa.