Project 245

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PEACH BOTTOM REACTOR

An attempt was made to review some of the physics of the Peach Bottom Reactor to determine if any serious problems existed from a physics standpoint. In order to do this a comparison was made with as many existing gas cooled and graphite moderated reactors as possible. In each of the reactors there are differences which tend to make a comparison difficult and somewhat questionable in value. However, a comparison with the reactors showed that the nuclear features of the Peach Bottom Reactor were within operating limits of the others. Many physics questions for the reactor as described in the Final Hazard Report are not answered and an attempt is made to point some of the more important ones out in the following paragraphs.

## I. Control Effects

In the clean cold condition of the reference reactor $k_{eff}$ is about 1.282, in the hot clean case $k_{eff}$ is 1.220. This gives a reactivity (delta k/k) to control in the clean cold condition of approximately 22.0 per cent. This reactivity is to be controlled by 37 neutron absorbent rods and built in burnable poisons. Enough excess control will be available in the control rods to make the reactor at least 3 per cent subcritical in the worst condition. In order to accomplish this the $k_{eff}$ with rods inserted must be about 0.962 in the cold clean core. At present sufficient physics calculations are not available to assure that this is true.

The average control per rod in this condition is about 0.675 per cent reactivity. The central rod in such a reactor would be approximately 2 times as effective as the average rod, therefore it would have roughly 1.35 per cent reactivity effect. This is still well below the 3.0 per cent specified and would tend to indicate that there is some degree of safety in the control system effectiveness. However, it must be kept in mind that these are calculated values and may vary in value upon actual measurement in the reactor.

Some of the information needed to evaluate the control effects for the reactor are:

1. The amounts of material, such as uranium, boron, and thorium, in the core at the beginning of core life and during the operating cycle.

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2. Control rod worths for various conditions of the core; this should include: excess reactivity ($\frac{\text{delta K}}{\text{K}}$) in the core with all rods withdrawn, the control ($\frac{\text{delta K}}{\text{K}}$) effect of all 37 rods fully inserted, the reactivity worth of the most centrally located rod with all others inserted, the reactivity worth of only the central rod, the variation of reactivity of a control rod as moved outward from the core center on the radial direction, the change in rod effectiveness during the operating life of the core, and a comparison of measured values with the calculated values wherever possible.

3. The possibility of including an additional shutdown device into the design of the reactor so that a backup control system is available in case of multiple rod failure.

## II <u>Reactor Stability</u>

Nuclear stability for large gas cooled, graphite moderated reactors has been demonstrated in some of the British reactors. However, since these reactors have uranium as a fertile material there will be some differences in the stability features of these reactors and the EGCR. Due to the size of the reactor core and the large reflector used it would appear that spatial instability of the neutron flux is unlikely. Instabilities that may arise in this reactor would be more likely to occur due to xenon transients, temperature or void effects.

Xenon transients were considered in the analysis of the reactor and certainly present a problem in regard to reactor excursions. However, the reactivity insertion represented in xenon removal by burnout is within the capability of the reactor control system and does not appear to represent a serious hazard.

The temperature coefficient of reactivity for the reflector is negative in value and remains so over the core lifetime. This has been checked in other reactors and a negative temperature coefficient for graphite reflectors is present in each case. The fuel temperature coefficient for the EGCR is negative at the beginning of core life and as the reactor operates it would appear to become positive. The magnitude of the positive coefficient at the end of the core life has not been determined for the planned core but it would appear that with the 70,000 MWD/MT burnup of fuel for the reactor that it may reach a positive value which would make it unsafe to operate the reactor.

The void effects for the reactor have not been evaluated in sufficient detail to permit an evaluation of the void coefficient of reactivity. The long core operating life, hence the large excess amount of fuel, means that the reactor is undermoderated in the initial condition. This could lead to a reactivity increase in case of addition of voids by spreading the core or removing a portion of the inner core. In general the type of coolant used will tend to avoid this situation but it has not been investigated thoroughly enough.

The Doppler effect on reactivity has been evaluated and does make a significant contribution to the over-all temperature coefficient of the reactor. There does not appear to be a significant problem due to Doppler effect but it would be informative to know the variation of this effect over the core lifetime.

Some of the things that should be determined in relation to reactivity effects on the reactor are:

1. The neutron lifetime and the change in neutron lifetime as U-233 builds up in the core.

2. The effect of voids on the reactivity, these should be uniformly distributed and as local voids.

3. The temperature coefficient of the fuel should be determined at various times during the fuel cycle to ascertain that it does not reach a positive value which may cause trouble.

III Fuel Damage

The fuel brunup for the reactor is greater than 70,000 MWD/MT. This value is several factors higher than existing reactors plan to burn their fuel. It is not known at present where damage to fuel of this type occurs due to atom burnup in the fuel structure. This problem should be fully investigated prior to high fuel burnup in this reactor.

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