Department of Energy
Washington, D.C. 20545
Docket No. 50-537
HQ:S:82:162

DEC 23 1982

Mr. Paul S. Check, Director
CRBR Program Office
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Check:

ADDITIONAL INFORMATION ON ENERGETICS ANALYSIS FOR THE CLINCH RIVER BREEDER REACTOR PLANT

Reference: Letter HQ:S:82:105, J. R. Longenecker to P. S. Check, "Summary of HCDA Energetics Meeting Held on September 21, 1982," dated October 15, 1982

Enclosed is the additional information requested at the September 21, 1982, subject meeting and identified in the reference letter. A list of the identified items are provided in Enclosure 1 with the Enclosures 2-6 containing the requested information.

Questions regarding this submittal may be directed to W. Pasko (FTS - 626-6096) of the Oak Ridge Project Office staff.

Sincerely,

John R. Longenecker

John R. Longenecker
Acting Director, Office of
Breeder Demonstration Projects
Office of Nuclear Energy

Enclosures

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ACTION ITEMS FOLLOWING THE SEPTEMBER 21, 1982
CRBRP/NRC HCDA ENERGETICS MEETING HELD AT
ARGONNE NATIONAL LABORATORY

1. Provide concise statement on TOP initiating ramp rates.

2. Provide EOC-3 neutronics data (data type transmitted to ANL will suffice).

3. Provide results of SAS sensitivity evaluation of best parameters for L6 and L7 in-pile tests.

4. Provide SAS 3D input deck with SLUMPY parameters used in response to QCS.760.

5. Recalculate plenum fission gas effects for EOC-4 with new sodium void worth.

6. Provide SAS 3D corrections made to complete item 5.

7. Provide TREAT test R-8 fuel pin data.

8. Provide analysis supporting fuel freezing upon entry to inner blanket assemblies.

9. Provide results of the GAP tests being performed at ANL when available.

Enclosure 2

Information in items 2, 3, 4, 6 and 7 of Enclosure 1 were previously transmitted to the NRC consultants. This information required transmission of computer tapes and computer input data.

Items 4,6, and 7: transmitted October 6, 1982 to Mr. W Bohl, Los Alomos National Laboratory

Item 3: transmitted October 8,1982, to Mr. H. Hummel, ANL

Item 2: transmitted November 9, 1982 to Mr. Hummel, ANL

Enclosure 3

This enclosure contains the response to item 1 of enclosure 1.

TOP INITIATING RAMP RATES

I. Introduction

Control rod withdrawal is a mechanism by which positive reactivity can be added to a nuclear reactor system. Thus, ejection and inadvertent withdrawal of a control rod have traditionally been considered in Design Basis Accident (DBA) evaluations for Light Water Reactors (LWRs).

Rod ejection accidents in CRBRP are precluded because the reactor coolant system is operated at essentially atmospheric pressure. In addition, the control rod weight is greater than the maximum coolant hydraulic forces so that intended or accidental operation of the Primary Heat Transport System (PHTS) pumps will not force a control rod out of the core if it is unlatched.

Inadvertent control rod withdrawal has been considered an appropriate overpower transient initiator to be analyzed as part of the CRBRP Design Basis Accident evaluation. Inadvertent control rod withdrawal would require a number of failures in the reactor control system. Section II includes a brief discussion of the current features of the reactor control system that prevent inadvertent control rod withdrawal. A more detailed description of the reactor control system is provided in Section 7.7 of the PSAR.

Due to the incorporation of the reactor control system design features discussed in Section II, inadvertent rod withdrawal is no longer an anticipated event. As discussed in Section III, both the primary and secondary Reactor Shutdown Systems include features to limit the extent of a rod or bank withdrawal.[1] However, as explained in Section IV, the inadvertent rod withdrawal case, analyzed as part of the Beyond Design Basis Accident evaluation (CRBRP-3, Volume 1), will be retained by the Project as an event characterizing the potential for energetics resulting from reactivity insertions in CRBRP.

II. Design Features that Prevent Inadvertent Rod Withdrawal

There are fifteen control rods (nine primary and six secondary) in CRBRP. Only six primary rods are maneuvered by the reactor control system to adjust reactor thermal power and compensate for fuel burnup. The remaining rods (3 primary and 6 secondary) are fully withdrawn from the core during power operation and therefore cannot add positive reactivity.

The control equipment for the six primary control rods is designed so that significant reactivity insertions due to inadvertent primary control withdrawal are extremely unlikely. Significant inadvertent rod motion is prevented by the use of

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[1] Some of the features discussed below have recently been adopted in the design. The PSAR will be modified to decribe them.

rod block circuits actuated by reactor overpower or rod out of position indications.

The reactor overpower rod block circuitry senses an overpower condition measured from the flux instrumentation associated with the secondary reactor shutdown system (separate measurements of flux and flux to flow ratio are provided) and sends a signal to the primary rod control equipment which will block any further withdrawal of the primary control rods.

There are two redundant trains of rod out of position rod block logic. One train uses rod position information provided by the absolute rod position indicators (ARPI) while the second train uses the diverse measurement of rod position provided by the relative rod position indicators (RRPI). Each rod out of position rod block train uses the rod position signals provided by the six primary rods used for reactor power control. From this an average bank position is calculated. The average bank position is compared to a bank position setpoint. If the average bank position signal exceeds the setpoint, signals are provided to the primary rod control equipment to prohibit any further rod motion until the system is reset. In addition, each individual rod position signal is compared with the average bank position signal. If any of the six individual rod position signals exceed the average bank position signal by a predetermined amount, the rod control equipment would prohibit further motion of any rod until the system is reset. In this manner the rod out of position rod blocks provide a defense against both single and multiple rod withdrawal scenarios.

Inadvertent rod or bank withdrawal is further prohibited by the features of the primary rod control equipment which are designed to always give priority to rod insertion command signals over rod withdrawal command signals. Several overspeed detection circuits are also provided in the primary rod control equipment. These circuits stop rod motion if an overspeed condition is detected.

The flux controller also has design features which decrease the likelihood that rod motion will occur due to failures of this equipment. A microprocessor is used to monitor the setpoint, feedback, output and other signals used and produced by the flux controller. Rate and direction signals to the primary rod control equipment are disabled in the event the microprocessor detects abnormal operation.

As a result of the above design features, at least five (5) separate failures to the primary control rod equipment would be required to allow inadvertent bank withdrawal or single rod withdrawal. Failure of both redundant trains of rod out of position rod block logic plus failure of both trains of reactor overpower rod block circuitry in conjunction with rod withdrawal due to operator error or an additional failure of the reactor control system (e.g. flux controller) is the most likely failure

sequence. This failure sequence would lead to single control rod withdrawal at 9 ipm resulting in a 2.3 cents/sec reactivity ramp rate or bank withdrawal at 4 ipm resulting in a 6.1 cents/sec reactivity ramp rate. For an even less likely sequence involving additional failures the withdrawal speeds would be limited to ten inches per minutes (2.6 cents/sec) for the single rod withdrawal and 5.5 inches per minutes (8.4 cents/sec) for bank withdrawal.

Although control rod withdrawal at a maximum mechanical speed of up to 45 ipm is a physical possibility, it would require a much greater number of failures than those discussed above. Thus, control rod withdrawal at the maximum mechanical speed is well beyond the spectrum of events appropriate for consideration as HCDA initiators.

Furthermore, if such an event were postulated, the rate of reactivity insertion by further control rod withdrawal is inherently limited by the control rod drive mechanism design.

The control rod is withdrawn by roller nuts engaging and rotating around the lead screw from which the rod is suspended. The roller nuts are held in engagement with the lead screw by the force from a magnetic field. Centrifugal force caused by rotation of the roller nuts opposes the magentic field force. If the roller nut rotational speed were to become excessive causing the control rod to be withdrawn at an excessive rate, the centrifugal force would overcome the magnetic force causing the roller nuts to disengage from the lead screw. This stops the lead screw and control rod from further withdrawal, thus terminating the reactivity insertion.

III. RSS Limitation of the Extent of Rod Withdrawal

In addition to the design features discussed in Section II, the CRBRP design includes two redundant, diverse, independent and fast-acting Reactor Shutdown Systems (called the Primary RSS and the Secondary RSS) that prohibit rod withdrawal upon receiving a logic signal to scram the reactor. The RSS logic uses proven electronic and pneumatic technology to automatically convert signals from the RSS sensors into scram signals.

The primary RSS uses integrated circuits in a local coincidence logic structure. In this local coincidence logic, when any two of three sensors monitoring the same plant parameter indicate conditions exceeding the established limits, a reactor scram is initiated. A separate logic channel is provided for each plant parameter being monitored by the primary RSS. The scram signals generated by the integrated circuits are used to trip circuit breakers feeding power to the Primary Control Rod Drive Mechanisms (PCRDMs). When power to the PCRDMs is interrupted, motion of the PCRDM rotors around the lead screws which support the primary control rods is terminated. Thus, the rod (or bank) withdrawal is terminated, independently of whether or not the

PCRDMs perform their scram function which inserts the rods into the core.

The secondary RSS logic uses discrete electronic components (e.g., transistors and capacitors) in a general coincidence logic structure and solenoid operated pneumatic valves as scram actuators. In this general coincidence logic, when at least one sensor in two of the three sensor channels (Channels A, B and C) indicate conditions exceeding the established limits, a reactor scram is initiated. The scram will occur even if the two sensors in the two tripped channels are monitoring different plant parameters. A secondary-to-primary rod interlock design feature precludes primary rod or bank withdrawal following secondary scram initiation. This is accomplished by providing circuitry in the secondary RSS that interrupts power to the motor-generator (M-G) sets which in turn supply driving power to the primary control rod drive mechanisms. If power is not supplied to the MG sets, they cannot supply power to the PCRDMs. When power to the PCRDMs is interrupted, motion of the rotors around the lead screws will not occur. Withdrawal of the primary control rods would be terminated by the secondary RSS independent of whether the primary RSS operates and regardless of whether or not the secondary control rods perform their function.

In conclusion, a reactivity insertion due to inadvertent rod or bank withdrawal would be prevented by reactor overpower and rod out of position rod blocks plus other reactor control system design features. In the extremely unlikely event that rod or bank withdrawal were not prevented by these design features, both a primary and a secondary RSS scram would be initiated when the key plant parameters that are sensitive to reactivity insertions reach their trip setpoint. Following either primary RSS or secondary RSS scram initiation rod and bank withdrawal would cease.

IV. Consideration of Inadvertent Rod Withdrawal as an HCDA Initiator

Unlikely and extremely unlikely events are not considered in conjunction with the assumed failure of both reactor shutdown systems as HCDA initiators. However, prior to incorporation of the current design features to prevent and limit rod withdrawal, continuous control rod withdrawal was considered an <u>anticipated</u> event capable of inserting a significant amount of reactivity. Thus, the project considered single control rod withdrawal with assumed failure of both reactor shutdown systems as a TOP HCDA initiator.

Because current design features make inadvertent rod (and bank) withdrawal extremely unlikely, the combination of inadvertent rod withdrawal (even when limited to the point of RSS trip) with assumed failure of both reactor shutdown systems would be exceedingly unlikely; outside the spectrum of events appropriate for consideration as HCDA initiators. Unlimited rod or bank

withdrawal with assumed failure of both reactor shutdown systems would be even less likely. Thus, it would be theoretically unnecessary to consider such reactivity insertions as potential HCDA initiators. Nonetheless, the control rod withdrawal case previously analyzed in CRBRP-3, Volume 1 will be retained by the Project as an event characterizing the potential for energetics resulting from reactivity insertions in CRBRP.

Enclosure 4

This enclosure contains the response to item 5 of enclosure 1.