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TO: V. D. Nixon

FROM: GM Roy, TF Robinson, EL Reed

Safety Control System for RDA-DC3SUMMARY

It is important that the design of the safety control system for RDA-DC3 be firmed up as soon as possible. This is necessary so that the detailed design of the graphite stack and other components can proceed. A recommendation for a safety system is given below. A meeting will be called to discuss the recommended system with personnel of the Technical Division and Manufacturing Department.

In some cases the numbers used in this document are to a good approximation only. J. R. Triplett of the Pile Physics group is making detailed calculations for the required number of rods and balls and is presently putting his results in documentary form. The various possible systems

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considered in making this recommendation have been discussed with A. B. Carson and J. R. Triplitt of Technical Section whose assistance will be used in establishing the exact pattern after approval of the basis has been obtained.

Requirements and Basis of the Control System

1. The safety control system should be adequate to hold a dry pile with Xenon fully decayed. A margin of safety of about 400 inhours should be available even though 10 % of the controls do not function.
 - a. For this requirement, the "worst" conditions to be met were taken to be as follows: The pile had been operated at 2200 MW and 100 inhours of flattening when it was shut down, due to loss of water, for an indefinite time.
2. Provisions must be made to remove the controls in a sufficiently short time to avoid an extended shutdown.
 - a. This time was taken as ten (10) minutes maximum.

Discussion

One design objective for RDA-DC-3 was the use of an all ball system for the safety system. The questionable feature of such a system from a mechanical and operating standpoint is the requirement that the balls be returned to the hoppers in about ten (10) minutes. This stringent requirement can be eliminated by having enough rods to provide control for shutdowns not involving severe emergencies and tripping balls only for those severe cases where rod control is not adequate. Any emergency which would trip the balls would be infrequent as well as so severe that the pile would be down for a period exceeding the minimum recovery time (about 30-45 minutes) and therefore would have to remain shut down for 30 hours or more. In such a case, the requirements for a ball return system can easily be met. The system proposed for RDA-DC-3 is a combination of about 60 ball slots with 35-40 rods.

Recommendations:

It is recommended that:

1. Approximately 60 ball slots be provided to meet requirement (1). This provides for about 2300 inhours even though about 10 % of the ball slots do not operate.
2. 35-40 vertical rods (1225-1425 inhours) be provided to meet requirement (2). This will be sufficient to shut the pile down under any emergency. If moderated rods are used, the number of rods can be reduced.

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Basis for Recommendation

Choice of 2300 inhours for the ball system resulted from consideration of cases A, B, & C below:

Case A.

1. The reactivity balance prior to emergency shut down is as follows:

<u>Reactivity</u>		<u>Control</u>	
Cold Clean Reactivity of		Xe @ 2200 MW and	
Pile with "C" Annulus	900 inhours	100 lb flattening	= 890 i.h.
Allowance for Pu buildup	180 inhours	Horiz. Rods	= 90 i.h.
Power Coefficient	0	Poison Columns	= 100 i.h.
	1080 inhours		1080 i.h.

2. Assume that an emergency arises because of total loss of water. This is conservatively taken as a gain of 1000 inhours. After sixty plus hours the Xenon has decayed to zero. The reactivity balance then becomes:

<u>Reactivity</u>		<u>Control</u>	
Pile as above	1080 i.h.	Xenon	0
Gain (Water Loss)	1000 i.h.	Hor. Rods & Poison	140 i.h. *
	2080		140
** Margin of Safety	360	Ball System	2300
	2440		2440

The power level of 2200 MW is certainly conservative as it is the most optimistic power level within the design limits of the water plant.

Case B.

Another case which can be examined is the effect of adding a power coefficient.

1. (a) For this case, the reactivity balance prior to emergency is:

<u>Reactivity</u>		<u>Control</u>	
	1080 inhours	Xe @ 2200 MW and	
Allowance for Power		400 lb flattening	= 860
Coefficient	300	Poison Columns	= 400
	1380 inhours	Rods (Horizontal)	= 120
			1380

* Initial poisoning was decreased by a factor of 1.35 to allow for shadowing effect of balls.

** Safety margin assumes only 90 % of ball slots operate.

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1. (b) After loss of both water and Xenon, the reactivity balance becomes

<u>Reactivity</u>		<u>Control</u>	
Power Coefficient	0	Xenon	0
Cold Clean, and Pu	1080	Horiz Rods & Poison	385 *
Gain (water loss)	<u>1000</u>	Balls	<u>2300</u>
	2080		2685
** Margin of Safety	<u>605</u>		
	2685		

Case C

Another consideration is the effect of enrichment. When operating with high enrichment, the margin of safety would be less than in Cases A and B because of the shadowing by the rods of the poison used to control the enrichment.

1. (a) As a rough example, consider the reactivity balance below:

<u>Reactivity</u>		<u>Control</u>	
Cold Clean with Pu	1080	Xe @ 2200 MW and 400 ih P	860
Power Coefficient	0	Poison	400
Enrichment	<u>300</u>	Horizontal Rods	<u>120</u>
	1380		1380

- (b) After loss of both water and Xenon:

<u>Reactivity</u>		<u>Control</u>	
	1380	Xe	0
	<u>1000</u>	Poison & Rods	385 *
	2380		<u>2300</u>
Margin	<u>305</u>		2685
	2685		

* Initial poisoning was decreased by a factor of 1.35 to allow for shadowing effect of balls.

** Safety margin assumes only 90 % of ball slots operate.

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