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SUBJECT: Discusses proposed use of 10 w/o gadolinia in enriched U rods. Informs that physics info gained from demonstration requested by NRC at 861210 meeting will be provided to extent available.

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H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261/LICENSE NO. DPR-23
USE OF 10 WEIGHT PERCENT GADOLINIA DURING CYCLE 12

Dear Sir:

On December 10, 1986, a meeting was held in Bethesda, Maryland, with members of the NRC staff, Carolina Power & Light Company (CP&L) representatives, and Exxon Nuclear representatives to discuss the use of 10 w/o Gadolinia in H. B. Robinson Steam Electric Plant, Unit No. 2 (HBR2) during Cycle 12 as a demonstration of using this concentration to support longer cycles in HBR2. The purpose of the meeting was to gain approval by the NRC of this program.

In summary, the program includes the use of 32 rods (four rods in each of eight assemblies) containing 10 w/o Gadolinia in enriched uranium. The uranium enrichment of these rods will be specified to assure that these rods are less limiting than the UO_2 rods. With this criteria, the safety analysis in support of Cycle 12 will not be impacted by the use of 10 w/o Gadolinia rods.

At the conclusion of the meeting, the NRC agreed that the demonstration of 10 w/o Gadolinia as described was acceptable. The NRC asked that the following commitments be made by CP&L and Exxon Nuclear:

1. Physics information gained from the demonstration be made available to the NRC.

2. Exxon Nuclear review the availability of critical experiments incorporating Gadolinia pins. If such information is available and applicable, Exxon Nuclear will provide a comparison of calculated versus experimental results to the NRC.

3. End-of-life physical measurements be made available to the NRC.

Carolina Power & Light Company will provide to the NRC, physics information at various points in Cycle 12 and end-of-life physical measurements to the extent that the data are available and meaningful. It is understood that any data provided are for information only and that CP&L's commitment extends only to provision of the data.

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The enclosure to this letter provides a more detailed discussion of demonstration program and a review against the criteria of 10 CFR 50.59.

Questions regarding this matter may be referred to Mr. R. W. Prunty at (919) 836-7318.

Yours very truly,

A. B. Cutter - Vice President
Nuclear Engineering & Licensing

ABC/JSK/kts (5107JSK)

Enclosure

cc: Dr. J. Nelson Grace (NRC-RII)
Mr. G. Requa (NRC)
Mr. H. Krug (NRC Resident Inspector - RNP)
Mr. Gary N. Ward (Exxon Nuclear)

ATTACHMENT

REVIEW OF THE USE OF 10 W/O GD_2O_3-UO_2 FUEL

IN H. B. ROBINSON UNIT NO. 2, CYCLE 12

The H. B. Robinson, Unit No. 2 nuclear plant is currently scheduled to begin Cycle 12 operation in the spring of 1987. The cycle design includes the use of 4 w/o, 6 w/o, and 10 w/o Gadolinia in UO_2 fuel. The use of up to 8 w/o Gadolinia has generically been approved by the NRC when Exxon Nuclear design models are used[1]. The use of the 10 w/o Gd_2O_3 in a domestic reactor provides an extension of the application of Gd_2O_3 that is within Exxon Nuclear design and manufacturing experience obtained in foreign reactors. The following details the planned use of the 10 w/o Gd_2O_3 in Cycle 12 and provides justification for its use.

Cycle 12 Design

The H. B. Robinson, Unit No. 2 reactor contains 157 fuel assemblies, each having a 15 x 15 fuel rod array. The assembly design is unchanged between the Gadolinia bearing and non-Gadolinia bearing fuel assemblies. The Cycle 12 reload consists of 48 Exxon Nuclear fuel assemblies. These assemblies have axial blankets of natural UO_2. Eight of these assemblies contain 4 rods each of 10 w/o Gadolinia bearing fuel. In the Cycle 12 reload, all Gadolinia bearing fuel pins contain 12 inches of natural UO_2 in the top and bottom of the fuel pin. In the non-Gadolinia bearing fuel, 6 inches of natural UO_2 is used in both the top and bottom of the fuel pin. The fuel assembly loading pattern is given in Figure 1.

The enrichment of the central regions for those rods which contain only UO_2 is 3.85 w/o U-235. For the fresh Gadolinia bearing rods, the enrichment has been reduced to assure that the Gadolinia bearing rods will not be the limiting rods in the core, even when accounting for the reduction in thermal conductivity caused by the Gd_2O_3 addition.

Figures 2 through 4 provide the quarter core radial power distributions for Cycle 12 exposures of 100 MWd/MTU, 7,000 MWd/MTU, and (EOC) 12,650 MWd/MTU, respectively. The Technical Specification limits on $F_{\Delta H}$ and F_Q^T are 1.65 and 2.32,

respectively, for H. B. Robinson, Unit No. 2. After applying manufacturing, engineering, and measurement uncertainities, the corresponding $F^N_{\Delta H}$ and F^N_Q limits are 1.59 and 2.15, respectively. As shown by Figures 2 through 4, there is margin to the Technical Specification limits. Also, as can be seen from these figures, the UO_2 rods in the assemblies containing Gd_2O_3 bearing fuel do at times become the peak power rods in the core, although they remain within the Technical Specification limits. At no time, however, do the rods containing Gd_2O_3 become the peak power rods in the core.

Justification for 10 w/o Gd_2O_3-UO_2 Fuel

Since the development of the currently approved Exxon Nuclear methodology for analyzing Gadolinia bearing fuel(1), Exxon Nuclear has continued to extend the development effort. This effort has addressed the material properties, irradiation performance, and the neutronics performance modeling. The material properties information and irradiation performance information(2) has been submitted to and approved by the NRC for Gadolinia concentrations up to 8 w/o. The data contained in this report are for thermal properties up to 12 w/o Gd_2O_3 and for PWR irradiation experience available to date, up to 10 w/o Gd_2O_3. Exposure levels of 51 MWd/KgU have been reached for assemblies containing 8 w/o Gd_2O_3 and 33 MWd/KgU for 10 w/o Gd_2O_3 bearing rods. These irradiation programs are continuing. Domestically, burnups of 43 MWd/KgU have been attained on 4 w/o Gadolinia bearing fuel and 8 MWd/KgU on 6 w/o Gadolinia bearing fuel. There have been no known failures of Exxon Nuclear Gadolinia bearing fuel rods in pressurized water reactors. This experience with Gd_2O_3 fuel provides assurance that the 10 w/o Gd_2O_3 fuel rods in H. B. Robinson, Unit No. 2 will perform satisfactorily. Exxon Nuclear neutronic methodology has been verified against operating data from both domestic and foreign reactors for which Exxon Nuclear supplies fuel. Domestically, fuel designs with up to 6 w/o Gd_2O_3 fuel rods, including over 96 6 w/o Gd_2O_3 and over 870 4 w/o Gd_2O_3 fuel rods in H. B. Robinson, Unit No. 2 and about 550 8 w/o Gd_2O_3 fuel rods and 32 10 w/o Gd_2O_3 fuel rods in foreign pressurized water reactors (as of November 1986) have been irradiated.

As presented by Exxon Nuclear to the NRC on December 10, 1986, the predicted to measured neutronic performance was within the normal expected calculational variation for all UO_2 cores. Therefore, Exxon Nuclear methodology is considered adequate for use in this demonstration of 10 w/o Gadolinia bearing fuel in H. B. Robinson, Unit No. 2.

Safety Question Review

Based upon the previous Exxon Nuclear experience, the small number of 10 w/o Gd_2O_3 bearing rods, and the reduction in U-235 enrichment in the Gd_2O_3 rods, the following conclusions can be made against the criteria of 10 CFR 50.59:

1. Is the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the safety analysis report increased?

   The assembly design is the same so the system response is unaffected, and there are only 32 10 w/o Gd_2O_3 rods which, because of the reduction in the U-235 content, are not expected to be limiting. Therefore, the probability of occurrence and the consequences of a previously evaluated accident are unchanged.

2. Is a possibility for an accident or malfunction of a different type than evaluated previously in the safety analysis report created?

   Because of the similar physical design and non-limiting behavior of the 10 w/o Gd_2O_3 bearing rods, the possibility of a different type of accident than previously evaluated is not created.

3. Is the margin of safety as defined in the basis for any Technical Specification reduced?

   The 10 w/o rods have been designed with a reduced U-235 enrichment to preclude these rods from being limiting. The non-Gd_2O_3 rods have been designed using NRC accepted techniques and satisfy the limits in the Technical Specifications. Therefore, the margin of safety as defined in any Technical Specification basis is not reduced.

Therefore, it is concluded that the inclusion of the 32 10 w/o Gd_2O_3 fuel rods in Cycle 12 of H. B. Robinson, Unit No. 2 does not involve an unreviewed safety question.

(5107JSK/kts)

References

1. XN-75-27(A), Supplement 4, "Exxon Nuclear Neutronics Design Methods for Pressurized Water Reactors," September 1986, Exxon Nuclear Company

2. XN-NF-85-92(P)(A), "Exxon Nuclear Uranium Dioxide/Gadolinia Irradiation Examination and Thermal Conductivity Results," September 1986, Exxon Nuclear Company

(5107JSK/kts)

H. B. Robinson Unit 2 Proposed
Cycle 12 Loading Plan

Figure 1

	H	G	F	E	D	C	B	A
8	26.3	15.0	0 A	24.8	25.1	0 A	14.3	7.0 PLSA
9	14.9	14.5	25.3	13.2	12.8	22.0	0 C	6.0 PLSA
10	0 A	25.2	25.4	0 B	25.6	11.8	0 D	
11	24.8	13.2	0 B	21.3	9.1	0 E	0	
12	25.1	12.8	25.6	9.1	12.5	26.8		
13	0 A	21.9	11.8	0 E	26.8	Assembly Exposure Gadolinia Design		
14	14.3	0 C	0 D	0				
15	7.0 PLSA	6.0 PLSA						

Gadolinia Configurations

A - 8 Pins of 4 w/o/4 Pins of 6 w/o
B - 8 Pins of 6 w/o/4 Pins of 10 w/o
C - 2 Pins of 4 w/o (Asymmetric)
D - 4 Pins of 4 w/o (Asymmetric)
E - 12 Pins of 4 w/o

	H	G	F	E	D	C	B	A
8	0.913	1.129	1.345 A	0.983	0.978	1.329 A	0.980	0.279 PLSA
9	1.130	1.113	0.983	1.161	1.141	1.021	1.124 C	0.245 PLSA
10	1.345 A	0.983	1.000	1.371 B	1.002	1.147	1.062 D	
11	0.983	1.160	1.371 B	1.034	1.178	1.201 E	0.806	
12	0.978	1.142	1.003	1.178	0.958	0.506		
13	1.329 A	1.022	1.147	1.201 E	0.504			
14	0.981	1.124 C	1.061 D	0.806				
15	0.279 PLSA	0.245 PLSA						

Assembly Relative Power
Gadolinia Design

Peak Assembly 1.37 (E10)

Peak $F^N_{\Delta H}$ = 1.46 (F11)

Peak F^N_Q = 1.74 (E10)

A - 8 Pins of 4 w/o/4 Pins of 6 w/o
B - 8 Pins of 6 w/o/4 Pins of 10 w/o
C - 2 Pins of 4 w/o (Asymmetric)
D - 4 Pins of 4 w/o (Asymmetric)
E - 12 Pins of 4 w/o

Figure 2 H. B. Robinson Unit 2 Cycle 12, Assembly Relative Power Distribution, 12,650 MWd/MTU, 2,300 MWt, 3-D XTGPWR

	H	G	F	E	D	C	B	A
8	0.939	1.211	1.248 A	0.986	0.998	1.257 A	0.983	0.224 PLSA
9	1.213	1.179	0.963	1.219	1.235	1.062	1.193 C	0.205 PLSA
10	1.250 A	0.965	0.951	1.264 B	1.012	1.220	1.100 D	
11	0.987	1.220	1.266 B	0.996	1.228	1.071 E	0.803	
12	1.000	1.238	1.015	1.229	0.948	0.427		
13	1.261 A	1.066	1.223	1.073 E	0.428			
14	0.986	1.196 C	1.102 D	0.804				
15	0.225 PLSA	0.205 PLSA						

Assembly Relative Power
Gadolinia Design

Peak Assembly = 1.27 (F11)

Peak $F^N_{\Delta H}$ = 1.48 (G14)

Peak F^N_Q = 1.94 (G14)

A - 8 Pins of 4 w/o/4 Pins of 6 w/o
B - 8 Pins of 6 w/o/4 Pins of 10 w/o
C - 2 Pins of 4 w/o (Asymmetric)
D - 4 Pins of 4 w/o (Asymmetric)
E - 12 Pins of 4 w/o

Figure 3 H. B. Robinson Unit 2 Cycle 12, Assembly Relative Power Distribution, 100 MWd/MTU, 2,300 MWt, 3-D XTGPWR

	H	G	F	E	D	C	B	A
8	0.885	1.127	1.333 A	0.961	0.970	1.362 A	0.989	0.248 PLSA
9	1.128	1.105	0.949	1.149	1.154	1.039	1.165 C	0.222 PLSA
10	1.334 A	0.950	0.948	1.299 B	0.990	1.193	1.118 D	
11	0.961	1.150	1.299 B	0.993	1.196	1.227 E	0.833	
12	0.971	1.155	0.991	1.196	0.956	0.483		
13	1.364 A	1.041	1.194	1.227 E	0.483			
14	0.990	1.165 C	1.118 D	0.833				
15	0.248 PLSA	0.222 PLSA						

Assembly Relative Power
Gadolinia Design

Peak Assembly = 1.36 (H13)

Peak $F^N_{\Delta H}$ = 1.50 (E13)

Peak F^N_Q = 1.83 (E13)

A - 8 Pins of 4 w/o/4 Pins of 6 w/o
B - 8 Pins of 6 w/o/4 Pins of 10 w/o
C - 2 Pins of 4 w/o (Asymmetric)
D - 4 Pins of 4 w/o (Asymmetric)
E - 12 Pins of 4 w/o

Figure 4 H. B. Robinson Unit 2 Cycle 12, Assembly Relative Power Distribution, 7000 MWd/MTU, 2,300 MWt, 3-D XTGPWR