AEC DISTRIBUTION FOR PART 50 DOCKET MATERIAL
(TEMPORARY FORM)

CONTROL NO: 2391

FILE: Appl.

FROM:	DATE OF DOC	DATE REC'D	LTR	MEMO	RPT	OTHER
Carolina Power & Light Raleigh, N. C. E. E. Utley	3-12-74	3-21-74	X			

TO:	ORIG	CC	OTHER	
John F. O'Leary	3 signed	37		SENT AEC PDR XXX SENT LOCAL PDR XXXX

CLASS	UNCLASS	PROP INFO	INPUT	NO CYS REC'D	DOCKET NO:
	XXX		XXX	40	50-261

DESCRIPTION:

Ltr requesting change to tech specs trans the following...

DO NOT REMOVE
ACKNOWLEDGED

PLANT NAME: H. B. ROBINSON UNIT #2

ENCLOSURES:

Pages changes to Tech Specs & description & evaluation of the gadolinia test assemblies during Cycle 3 operations

(40 cys encl rec'd)

FOR ACTION/INFORMATION 3-21-74 GMC

BUTLER(L)	SCHWENCER(L)	ZIEMANN(L)	REGAN(E)
W/ Copies	W/ Copies	W/ Copies	W/ Copies
CLARK(L)	STOLZ(L)	DICKER(E)	
W/ Copies	W/ Copies	W/ Copies	W/ Copies
GOLLER(L)	VASSALLO(L)	KNIGHTON(E)	
W/ Copies	W/ Copies	W/ Copies	W/ Copies
KNIEL(L)	✓ SCHEMEL(L)	YOUNGBLOOD(E)	
W/ Copies	W/9 Copies	W/ Copies	W/ Copies

INTERNAL DISTRIBUTION

✓ REG FILE	TECH REVIEW	DENTON	LIC ASST	A/T IND
✓ AEC PDR	HENDRIE	GRIMES	DIGGS (L)	BRAITMAN
✓ OGC, ROOM P-506A	SCHROEDER	GAMMILL	GEARIN (L)	SALTZMAN
✓ MUNTZING/STAFF	MACCARY	KASTNER	GOULBOURNE (L)	B. HURT
CASE	KNIGHT	BALLARD	LEE (L)	PLANS
GIAMBUSSO	PAWLICKI	SPANGLER	MAIGRET (L)	MCDONALD
BOYD	SHAO		SERVICE (L)	✓ DUBE w/Input
MOORE (L)(BWR)	STELLO	ENVIRO	SHEPPARD (E)	INFO
DEYOUNG(L)(PWR)	HOUSTON	MULLER	SMITH (L)	C. MILES
✓ SKOVHOLT (L)	NOVAK	DICKER	TEETS (L)	B. KING
P. COLLINS	ROSS	KNIGHTON	WADE (E)	
DENISE	IPPOLITO	YOUNGBLOOD	WILLIAMS (E)	✓ E. COUPE Ltr
REG OPR	TEDESCO	REGAN	WILSON (L)	
✓ FILE & REGION(3)	LONG	PROJECT LDR	S. REED (L)	
MORRIS	LAINAS			
STEELE	BENAROYA	HARLESS		
	VOLLMER			

EXTERNAL DISTRIBUTION

✓ 1 - LOCAL PDR HARTVILLE, SC
✓ 1 - DTIE(ABERNATHY)
✓ 1 - NSIC(BUCHANAN)
1 - ASLB(YORE/SAYRE/ WOODARD/"H" ST.
✓ 16 - CYS ACRS ~~HOLDING~~
Sent to Lic Asst Teets 3-21-74

(1)(2)(10)-NATIONAL LAB'S
1-ASLBP(E/W Bldg, Rm 529)
1-W. PENNINGTON, Rm E-201 GT
1-CONSULTANT'S NEWMARK/BLUME/AGBABIAN
1-GERALD ULRIKSON...ORNL

1-PDR-SAN/LA/NY
1-GERALD LELLOUCHE BROOKHAVEN NAT. LAB
1-AGMED(Ruth Gussman) RM-B-127, GT.
1-RD..MULLER..F-309 GT

Regulatory File Cy.

CP&L

Carolina Power & Light Company

March 12, 1974

File: NG-3514

Serial: NG-74-314

Mr. John F. O'Leary, Director
Directorate of Licensing
Office of Regulation
U. S. Atomic Energy Commission
Washington, D. C. 20545

50-261

RECEIVED MAR 21 1974

Dear Mr. O'Leary:

H. B. ROBINSON UNIT NO. 2
LICENSE DPR-23
<u>CONTINUED IRRADIATION OF GADOLINIUM TEST ASSEMBLIES</u>

During the second operating cycle of the H. B. Robinson Plant, four test assemblies, each containing sixteen fuel rods with gadolinia dispersed in the fuel pellets, were authorized by the AEC for irradiation. Continued irradiation of the gadolinia test rods past the end of Cycle 2 was prohibited by a change to Section 5.3.1.3 of the Technical Specifications.

By copy of this letter, Carolina Power & Light Company requests a revision to the Technical Specifications to allow continued irradiation of up to twelve gadolinia-bearing fuel rods in each of the four test assemblies during Cycle 3. The remaining four rods in each assembly will be removed for testing and replaced with standard unirradiated uranium dioxide fuel rods. The proposed change is attached in the form of page changes to the Technical Specifications.

Also attached is a description and evaluation of the gadolinia test assemblies during Cycle 3 operations. Contained in this attachment is an evaluation of the thermal and hydraulic, nuclear and material performance of the fuel rods, the behavior of Gd_2O_3-UO_2 with regard to densification and a safety evaluation of the behavior of the gadolinia-bearing fuel rods during the postulated ejected control rod accident. The conclusion is reached that inclusion of the four test assemblies containing UO_2-Gd_2O_3 fuel rods in Robinson Cycle 3 will not affect safety considerations, nor make it necessary to change the safety analyses and related engineering information submitted previously in WCAP-8243 at the uprated power level of 2300 MWt.

DOCKETED USAEC MAR 21 1974

2391

336 Fayetteville Street • P. O. Box 1551 • Raleigh, N. C. 27602

Currently, Cycle 2 is scheduled to end on May 4, 1974. In order for us to properly schedule removal and replacement of the test assemblies during the refueling outage, we would need to know the status of the gadolinia-bearing rods no later than May 15, 1974. We, therefore, would appreciate your prompt attention to this request.

Yours very truly,

E. E. Utley
Vice-President
Bulk Power Supply

DBW:mvp
Attachment

cc: Messrs. N. B. Bessac
T. E. Bowman
B. J. Furr
W. B. Howell
D. V. Menscer
D. B. Waters

5.3 REACTOR

5.3.1 Reactor Core

5.3.1.1 The reactor core contains approximately 71 metric tons of uranium in the form of slightly enriched uranium dioxide pellets. The pellets are encapsulated in Zircaloy - 4 tubing to form fuel rods. Two thirds of the initial core loading will contain pre-pressurized fuel rods. Subsequent core loadings will consist of all pre-pressurized fuel rods. The reactor core is made up of 157 fuel assemblies. Each fuel assembly contains 204 fuel rods.[1]

5.3.1.2 The average enrichment of the initial core is a nominal 2.50 weight percent of U-235. Three fuel enrichments are used in the initial core. The highest enrichment is a nominal 3.10 weight percent of U-235.[2]

5.3.1.3 Reload fuel will be similar in design to the initial core. The enrichment of reload fuel will be no more than 3.5 weight percent of U-235.

Four test assemblies containing gadolinia-bearing fuel rods may be loaded in the core during Cycle 3 operations. The test assemblies, the fuel rods in each assembly, and their locations in the core must conform to the descriptions given in Reference 8 and Reference 9. The test rods must be replaced with rods containing standard fuel before commencing operation for Cycle 4.

5.3.1.4 Burnable poison rods are incorporated in the initial core. There are 816 poison rods in the form of 12-rod clusters, which are located in vacant rod cluster control guide tubes.[3] The burnable poison rods consist of borated pyrex glass clad with stainless steel.[4]

5.3.1.5 There are 45 full-length RCC assemblies and 8 partial-length RCC assemblies in the reactor core. The full-length RCC assemblies contain 144 inch length of silver-indium-cadmium alloy clad with

the stainless steel. The partial-length RCC assemblies contain a 36 inch length of silver-indium-cadmium alloy with the remainder of the stainless steel sheath filled with Al_2O_3.[5]

5.3.1.6 Up to 10 grams of enriched fissionable material may be used either in the core, or available on the plant site, in the form of fabricated neutron flux detectors for the purposes of monitoring core neutron flux.

5.3.2 Reactor Coolant System

5.3.2.1 The design of the Reactor Coolant System complies with the code requirements.[6]

5.3.2.2 All piping, components and supporting structures of the Reactor Coolant System are designed to Class I requirements.

5.3.2.3 The nominal liquid volume of the Reactor Coolant System, at rated operating conditions, is 9343 cubic feet.[7]

References

(1) FSAR - Section 3.2.3
(2) FSAR - Section 3.2.1
(3) FSAR - Section 3.2.1
(4) FSAR - Section 3.2.3
(5) FSAR - Sections 3.2.1 & 3.2.3
(6) FSAR - Table 4.1-9
(7) FSAR - Table 4.1.1
(8) 'Description and Evaluation of Test Assemblies Containing Gadolinia Bearing Fuel Rods' submitted with letter dated January 5, 1973, from CP&L to the Director of Licensing."
(9) "Description and Evaluation of Test Assemblies Containing Gadolinia Bearing Fuel Rods - H. B. Robinson Unit No. 2 Cycle 3" submitted with letter dated March 12, 1974, from CP&L to the Director of Licensing.

DESCRIPTION AND EVALUATION OF TEST ASSEMBLIES CONTAINING GADOLINIA BEARING FUEL RODS -- H. B. ROBINSON UNIT NO. 2 CYCLE 3

INTRODUCTION

As part of its continuing core performance improvement program, Westinghouse proposes to continue irradiation of four fuel assemblies as part of Region 4 of the H. B. Robinson Unit No. 2 reactor for the purpose of evaluating the in-reactor performance of uranium dioxide pellets containing dispersed gadolinia (Gd_2O_3). The fuel assemblies containing the UO_2-Gd_2O_3 are designed to facilitate interim and end-of-life fuel evaluation. The fuel rods can be removed, non-destructively examined, and reinserted at the end of intermediate fuel cycles. At the end-of-life (end of reactor cycle 4) or any intermediate refueling shutdown the rods can be removed for off-site destructive examinations in a hot cell laboratory. Plans call for removing and replacing up to 16 gadolinia rods (4 per assembly) prior to reactor cycle 3 operation. The replacement rods will be standard unirradiated UO_2 fuel rods.

The original purpose of the test was primarily to confirm the analytical nuclear design methods relative to Gd_2O_3 bearing fuel rods. The removal rate of gadolinium poison (high cross section) isotopes is the primary design parameter to be verified. The data base for this objective will be obtained during reactor cycle 2. The purpose for continuing the irradiation in reactor cycle 3 is primarily to obtain material performance information.

This submittal covers only reactor cycle 3 operation of the test assemblies containing gadolinia bearing fuel rods. Reference 1 presents the overall description of the test assemblies as well as performance during reactor cycle 2. Reference 2 presents a description of the overall H. B. Robinson Unit No. 2 cycle 3 operation.

DESIGN DESCRIPTION

General

The assemblies containing 3.0 w/o gadolinium will be installed in the E-8 and L-8 core positions (see Figure 1) during cycle 3. Assemblies containing 1.85 w/o gadolinium will be installed in core positions H-5 and H-11 during cycle 3. Each of the gadolinia assemblies will contain sixteen borosilicate burnable poison rods during cycle 3.

Thermal and Hydraulic

The peak gadolinia fuel rod power is limited to 80% of the non-gadolinia bearing fuel rod design power limit. This 20% reduction in allowed power covers both the reduced melting point of gadolinia fuel and the reduced thermal conductivity with approximately half of the difference due to each property. This is considered converyative. For example, the melting point used in the cycle 2 evaluation[1] was 4530°F (unirradiated) whereas the best estimate melting point is about 5000°F.

The effect of gadolinium irradiation products (e.g., terbium) on fuel thermal properties is not considered significant. Neutron capture by gadolinium results in another gadolinium isotope. The irradiation of gadolinium produces a stable gadolinium isotope in most cases and thus has no effect on the thermal properties of the fuel. Those unstable gadolinium isotopes which decay to terbium (Gd-159 and Gd-161) have very low production rates because of the low neutron capture cross sections of the parent gadolinium isotope (Gd-158 is 2.4 barns and Gd-160 is 0.8 barns). Terbium, another rare earth with properties similar to gadolinium, replaces gadolinium atoms on a one-for-one basis so there is not net increase in the number of atoms. Terbium can, in turn, decay to dysprosium, another rare earth. The 20% reduction in allowed power for gadolinia bearing fuel is considered sufficient to account for any small differences in the effect of gadolinium, terbium, and dysprosium on fuel thermal properties.

Nuclear

The cycle 3 nuclear design of the gadolinia assemblies is similar to standard fuel in that the high cross section gadolinium isotopes have essentially burned out during reactor cycle 2.

The predicted cycle 3 core power distributions at the beginning and end of the cycle are given in Figure 2. As previously noted, the gadolinia assemblies will contain borosilicate burnable poison rods during cycle 3. The core distribution of borosilicate burnable poison rods is given in Figure 1. Figure 3 gives the predicted peak gadolinia rod power relative to the core average rod power. The peak power (predicted) rod of each gadolinia enrichment is given as a function of cycle 3 burnup. Also shown in Figure 3 is the gadolinia fuel design limit of 1.15 (1.435 x 0.8). Although the predicted gadolinia assembly power is high at the end of reactor cycle 3 (Figure 2), the highest power gadolinia rods are predicted to be nearly equal to the core average rod. The minimum margin between the peak gadolinia rod power and the design limit is approximately 13%.

Material Performance

Spatial redistribution of gadolinium within the fuel rod due to thermal gradients or irradiation is not considered to be a problem. As noted in Reference 1, there was no apparent radial variation of gadolinia density after irradiation to 4100 MWD/MTU and 6200 MWD/MTU. While no

information is available on gadolinia redistribution at higher burnups, it is judged that migration would have been detectable at 6200 MWD/MTu if such migration is significant. As noted in the introduction, material performance information is a primary purpose of the continued irradiation of the assemblies.

Densification

Densification of gadolinia bearing fuel material is expected to occur. There is no reason to expect that the small amounts of Gd_2O_3 contained in the fuel will affect the amount of densification. Reference 2 covers densification for the standard fuel. The power spike resulting from densification is applied to F_Q. Since the peak power in the gadolinia fuel rods is less than the remaining fuel rods, the densification analysis in Reference 2 is directly applicable for the gadolinia rods.

Safety Evaluation

The safety evaluation presented in Reference 1 remains valid except for the ejected control rod. The ejected control rod evaluation is presented below.

As ejected control rod results in extensive local effects in addition to the gross core effects, control rods cannot be inserted in the assemblies with gadolinia bearing fuel rods. The gadolinia assemblies are, however, adjacent to the highest worth ejected rod during cycle 3. The ejected control rod concern relative to gadolinia bearing fuel rods is center melt.

Analysis of the ejected control rod accident in Reference 2 indicates center melting could occur in UO_2 fuel for the full power beginning of cycle 3 case. Mitigating the effect of an ejected control rod on the gadolinia fuel is the gadolinia rod power. The predicted power in the gadolinia rods is considerably less than the UO_2 rods. This is particularly true at the beginning of cycle 3 when the borosilicate burnable poison rods are most effective (see Figure 3).

The effect of an ejected control rod on the gadolinia fuel rods is expected to be no more severe than the effect on UO_2 fuel rods due to the relative power in the rods in steady state.

CONCLUSION

It is concluded that inclusion of these four assemblies containing up to twelve (12) UO_2-Gd_2O_3 fuel rods each in H. B. Robinson Unit 2 cycle 3 will not affect safety considerations, nor make it necessary to change the safety analyses and related engineering information submitted in Reference 2.

REFERENCES

(1) "Description and Evaluation of Test Assemblies Containing Gadolinia Bearing Fuel Rods," submitted with letter dated January 5, 1973, from CP&L to the Director of Licensing.

(2) "H. B. Robinson Unit 2, Justification for Operation at 2300 MWt," December 1973, WCAP 8243 (Westinghouse Proprietary Class 2) and WCAP 8244.

H. B. Robinson Unit 2

Cycle 3

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							5	5	5						
2					5	5	5 / 16	4	5 / 16	5	5				
3				5	5 / 12	4	4	4	4	4	5 / 12	5			
4			5	6	4 / 12	6	6 / 16	6	6 / 16	6	4 / 12	6	5		
5		5	5 / 12	4 / 12	6	4 / 16	6	4B / 16	6	4 / 16	6	4 / 12	5 / 12	5	
6		5	4	6	4 / 16	6	4 / 16	6	4 / 16	6	4 / 16	6	4	5	
7	5	5 / 16	4	6 / 16	6	4 / 16	6	6 / 8	6	4 / 16	6	6 / 16	4	5 / 16	5
8	5	4	4	6	4B / 16	6	6 / 8	4A	6 / 8	6	4B / 16	6	4	4	5
9	5	5 / 16	4	6 / 16	6	4 / 16	6	6 / 8	6	4 / 16	6	6 / 16	4	5 / 16	5
10		5	4	6	4 / 16	6	4 / 16	6	4 / 16	6	4 / 16	6	4	5	
11		5	5 / 12	4 / 12	6	4 / 16	6	4B / 16	6	4 / 16	6	4 / 12	5 / 12	5	
12			5	6	4 / 12	6	6 / 16	6	6 / 16	6	4 / 12	6	5		
13				5	5 / 12	4	4	4	4	4	5 / 12	5			
14					5	5	5 / 16	4	5 / 16	5	5				
15							5	5	5						

Key: x (upper right of box) ← Region No.; y (lower left of box) ← No. Burnable Poison Rods

Figure 1

Core Loading Arrangement

.904 .907	.999 1.047	1.090 1.105	* .987 1.166	1.155 1.113	1.254 1.052	1.093 .971	.778 .740
1.001 1.047	1.113 1.081	1.032 1.162	1.093 1.139	.920 1.094	1.213 1.048	.935 .976	.600 .607
1.097 1.105	1.038 1.166	1.114 1.142	1.051 1.180	1.171 1.114	1.269 1.061	.999 .867	
**1.003 1.158	1.096 1.139	1.051 1.181	1.136 1.135	1.076 1.124	.985 1.023	.671 .636	
1.142 1.113	.915 1.097	1.168 1.117	1.076 1.126	.971 .966	.710 .712		
1.175 1.023	1.197 1.052	1.263 1.065	.982 1.025	.709 .712			
1.068 .974	.920 .980	.990 .870	.667 .637				
.764 .743	.590 .609						

Beginning of Cycle
End of Cycle

* Gd-3 w/o
** Gd-1.85 w/o

Figure 2

Predicted Assembly Power Distribution
H. B. Robinson Unit 2 Cycle 3

Figure 3

Predicted Gadolinia Rod Power vs. Burnup

H. B. Robinson Unit 2 Cycle 3