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R.E. GINNA NUCLEAR PLANT CYCLE 12 SAFETY ANALYSIS REPORT FOR LOW TEMPERATURE AND PRESSURE

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EXXON NUCLEAR COMPANY, Inc.

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SAFETY ANALYSIS REPORT
FOR LOW TEMPERATURE AND PRESSURE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

R. E. GINNA NUCLEAR PLANT CYCLE 12
SAFETY ANALYSIS REPORT
FOR LOW TEMPERATURE AND PRESSURE

PROLOGUE

In the fall of 1982, Rochester Gas and Electric Company (RG&E) is scheduling a reduction in both coolant temperature and system pressure for the R. E. Ginna plant. This report addresses the safety analysis evaluation for Cycle 12 at low temperature and pressure conditions. Reports supplied previously for Cycle 12 included the neutronic analyses associated with the Preliminary and Final Scheduled Delivery Date Notices, (PWR:023:80 and PWR:003:81), the Cycle 12 Fuel Cycle Design Analyses, XN-NF-81-66 (P), the Cycle 12 Safety Analysis Report at normal conditions, XN-NF-81-94, and the Cycle 12 Startup and Operations Report, XN-NF-82-41 (P). INCORE computer decks required for Cycle 12 operations will be supplied as the cycle progresses.

R. E. GINNA NUCLEAR PLANT CYCLE 12
SAFETY ANALYSIS REPORT
FOR LOW TEMPERATURE AND PRESSURE

1.0 INTRODUCTION AND SUMMARY

The R. E. Ginna nuclear plant began Cycle 12 operation in May of 1982 at normal temperature and pressure (NTP) conditions ($T_{avg} = 573.5^oF$ and pressure = 2,250 psia). In the fall of 1982, Rochester Gas and Electric (RG&E) is scheduling a 15^oF reduction in temperature and a 250 psia reduction in pressure for the plant. This report addresses the safety analysis evaluation for operation of Cycle 12 at the lower temperature and pressure conditions (LTP). The analysis bounds Cycle 12 operation between cycle exposures of 0 MWD/MT and 9,400 MWD/MT. The R.E. Ginna core contains four (4) regions of fuel supplied by Exxon Nuclear Company (ENC). The Cycle 12 fresh fuel loading consists of 12 ENC assemblies from Region 13 (Batch XN-4 with zircaloy guide tubes) and twelve (12) ENC assemblies from Region 14 (Batch XN-5 with zircaloy guide tubes). The remainder of the core contains 24 once-burnt assemblies with zircaloy guide tubes and 4 once-burnt, 32 twice-burnt, and 33 thrice-burnt ENC assemblies with stainless steel guide tubes in addition to four (4) twice-burnt Westinghouse mixed oxide (MOX) assemblies.

The characteristics of the fuel and of the reloaded core result in conformance with existing Technical Specification limits regarding shutdown margin provisions and thermal limits. This document provides the neutronic and control rod ejection analyses for the plant during Cycle 12 operation with the lower temperature and pressure conditions. The ENC fuel design(1) for Batch XN-5 is very similar to the design of Batch XN-4. The dimensions are unchanged, however, tighter tolerances on the fuel and clad allow Batch XN-5 to go to higher burnup than the previous ENC reload batches. The Cycle 12 analysis for low temperature and pressure conditions is determined to be bounded by the previous Plant Transient Analysis(2,3,4). Likewise, the ECCS analysis(5,6) is also applicable to Cycle 12 operation for low temperature and pressure conditions. The consequences of the rod ejection accident for Cycle 12 at LTP are similar to those calculated for Cycles 8(7), 9(8), 10(9), 11(10), and 12(11,12) (NTP).

2.0 OPERATING HISTORY OF THE REFERENCE CYCLE

R. E. Ginna Cycle 11 has been chosen as the reference cycle with respect to Cycle 12 due to the close resemblance of the neutronic characteristics between these two cycles. Cycle 11 operation began on June 19, 1981 and was terminated during the February 1982 outage. The core had accrued a Cycle 11 burnup of 7,100 MWD/MT. The Cycle 11 loading included 28 fresh ENC fuel assemblies. Remaining assemblies in the core consisted of 89 exposed ENC assemblies and 4 exposed Westinghouse mixed oxide assemblies.

The measured power peaking factors at hot full power, equilibrium xenon conditions, remained considerably below the Technical Specification limits throughout Cycle 11. The total nuclear peaking factor, F_Q^N, and the radial nuclear pin peaking factor $F_{\Delta H}^N$, remained below 1.75 and 1.48, respectively. Cycle 11 operation was typically rod free with the D control bank positioned in the range of 215 to 218 steps, 225 steps being fully withdrawn. It is anticipated the control bank insertions throughout Cycle 12 will be similar to those in Cycle 11.

The critical boron concentration as calculated by ENC for Cycle 11 agreed to within about 35 ppm compared to the observed values (see Figure 2.1). Also the predicted power distributions typically agreed to within ±3 percent of the measured values (see Figure 2.2 for typical comparison).

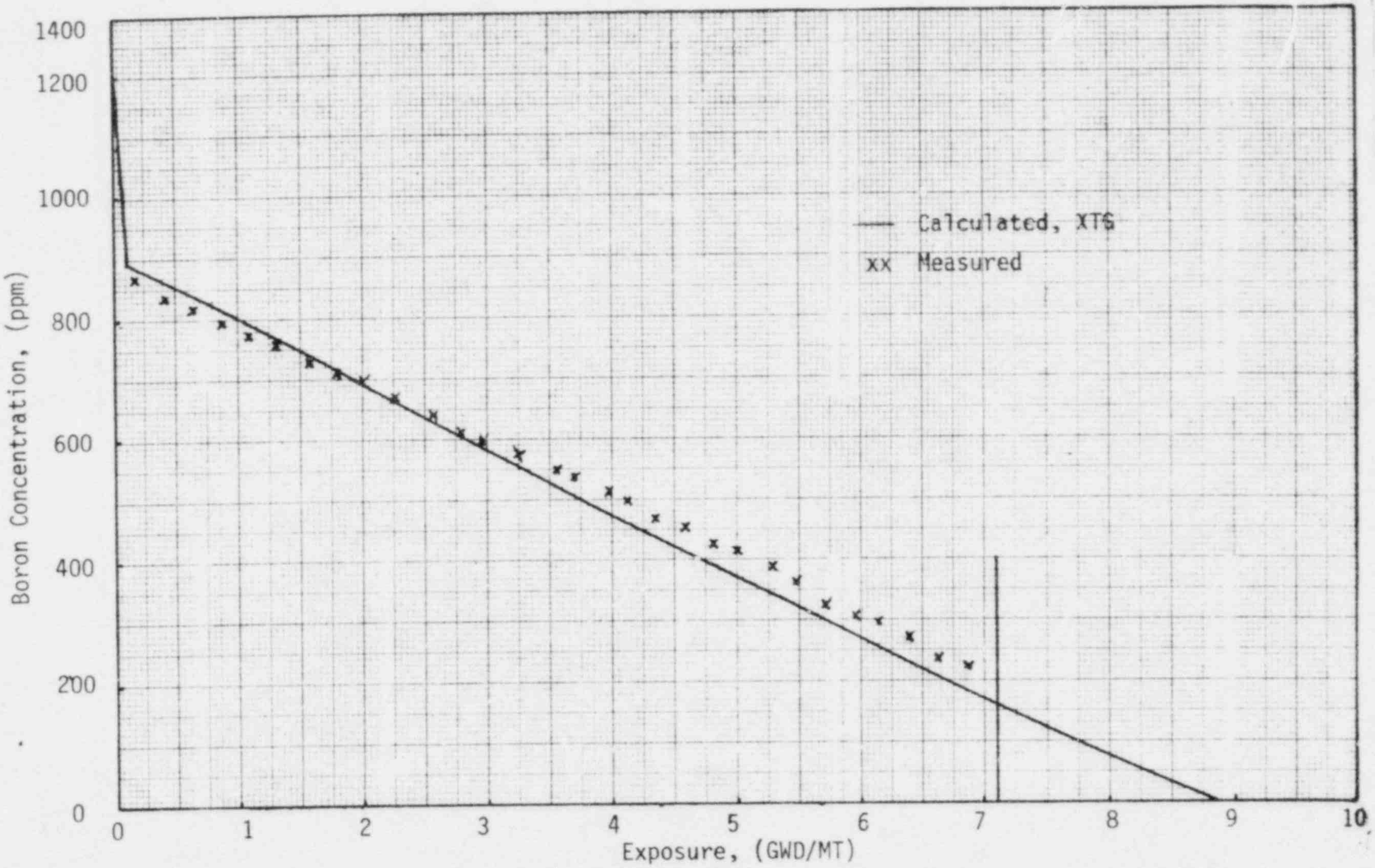

Figure 2.1 R. E. Ginna Cycle 11 Critical Boron Concentration vs. Exposure, ARO

.906 .890 +1.8	1.008 .991 +1.7	1.214 1.190 +2.0	1.072 1.048 +2.3	1.028 1.020 +0.8	.948 .943 +0.5	.705* .695 +1.4
1.005 .991 +1.4	1.238 1.229 +0.7	1.036 1.022 +1.4	1.091 1.080 +1.0	1.271 1.270 +0.1	1.148 1.138 +0.9	.639 .624 +2.4
1.210 1.190 +1.7	1.032 1.026 +0.6	.946 .952 -0.7	1.303 1.307 -0.3	1.101 1.097 +0.4	.962 .954 +0.8	
1.065 1.048 +1.6	1.090 1.086 +0.4	1.291 1.310 -1.5	.968 .976 -0.8	1.156 1.159 -0.3	.436 .427 -0.3	
1.034 1.020 +1.4	1.273 1.273 +0.0	1.086 1.099 -1.2	1.145 1.159 -1.2	.780 .788 -1.1		
.938 .943 -0.6	1.132 1.140 -0.7	.948 .955 -0.7	.433 .438 -1.1	Measured Calculated PDQ $\frac{m-c}{c} \times 100$		
.680* .697 -2.5	.613 .624 -1.7					

* Mixed Oxide Fuel

	Peaking Maximum Calculation	Measurement
F_Q	1.596	1.599
$F_{\Delta H}$	1.431	1.423
F_R	1.310	1.303

Figure 2.2 R. E. Ginna Cycle 11 Power Distribution INCORE vs. PDQ Prediction, 3,600 MWD/MT

3.0 CYCLE 12, REVISED TEMPERATURE AND PRESSURE OPERATIONS COMPARED TO OPERATIONS AT NORMAL TEMPERATURE AND PRESSURE CONDITIONS

The R. E. Ginna nuclear plant is currently operating in Cycle 12 at normal temperature and pressure conditions. Comparisons between early Cycle 12 neutronic calculations to measured data at normal temperature and pressure conditions are presented in this section. In addition, calculated data at the revised temperature and pressure conditions for early Cycle 12 operations are compared against the calculated and measured data at normal conditions. The comparisons show a slight increase in assembly power (~2%) in the edge assemblies and an increase of ≃20 ppm of dissolved boron with the revised conditions.

Cycle 12 operation began on May 25, 1982, and as of June 21, 1982, the core had accrued about 700 MWD/MT of burnup. The Cycle 12 loading includes twenty-four (24) fresh ENC fuel assemblies. Remaining assemblies in the core consist of ninety-three (93) exposed ENC assemblies and four (4) exposed Westinghouse mixed oxide assemblies.

The measured power peaking factors at hot full power, equilibrium xenon conditions are considerably below the Technical Specification limits in Cycle 12. The total nuclear peaking factor, F_Q^N and the radial nuclear pin peaking factor, $F_{\Delta H}^N$, are measured to be below 1.71 and 1.46, respectively. The calculated values of F_Q^N and $F_{\Delta H}^N$ at normal temperature and pressure conditions (NTP) are 1.67 and 1.43, respectively. At the revised low temperature and pressure conditions (LTP) F_Q^N and $F_{\Delta H}^N$ are calculated to be 1.71 and 1.44, respectively. These values are very close. The calculated assembly power distribution at NTP and the measured assembly power distribution at NTP is shown in Figure 3.1 at a cycle burnup of 555 MWD/MT. A comparison of the calculated assembly powers between the NTP and LTP core with the ENC core simulator model at 1,000 MWD/MT is shown in Figure 3.2. The power distributions are very similar.

The critical boron concentration at NTP as calculated by ENC for Cycle 12 is agreeing to within 16 ppm at 700 MWD/MT. At startup the hot zero power measured critical boron was within 5 ppm of the calculated value. The calculated boron rundown curve at NTP, LTP, and the measured values at NTP are shown in Figure 3.3.

	G	F	E	D	C	B	A
7	.95 .93 2.11	1.20 1.17 2.50	.88 .87 1.14	1.12* 1.13 -.89	.99 1.00 -1.01	1.26 1.27 -.79	.87 .87 0.0
8	1.21 1.18 2.48	1.12 1.09 2.68	.93 .91 2.15	.97 .97 0.0	1.28 1.29 -.78	1.04 1.03 .96	.68 .67 1.47
9	.88 .87 1.14	.92 .91 1.09	1.29 1.26 2.33	1.25 1.25 0.0	1.17 1.17 0.0	.93 .93 0.0	
10	1.12* 1.13 -.89	.97 .98 -1.03	1.25 1.25 0.0	1.15 1.15 0.0	1.09 1.09 0.0	.42 .42 0.0	
11	.99 1.00 -1.01	1.28 1.30 -1.56	1.16 1.17 -.86	1.09 1.10 -.92	.74 .74 0.0	Measured Calculated $\frac{M-C}{M} \times 100$	
12	1.28 1.27 .78	1.00 1.02 -2.00	.87 .93 -6.90	.42 .42 0.0			
13	.87 .87 0.0	.67 .67 0.0					

* Mixed Oxide Fuel

Peaking

	Maximum Calculation	Measurement
F_Q	1.60	1.70
$F_{\Delta H}$	1.43	1.46
F_R	1.30	1.28

Figure 3.1 R. E. Ginna Cycle 12 Power Distribution
INCORE vs. PDQ Prediction, Octant Averaged, 555 MWD/MT

G	F	E	D	C	B	A	
.978 .972 .613	1.219 1.211 .656	.914 .906 .875	1.125* 1.115 .889	.988 .992 -.405	1.235 1.249 -1.134	.885 .899 -1.582	7
1.235 1.227 .648	1.122 1.103 1.693	.930 .924 .645	.992 .989 .302	1.267 1.274 -.552	.998 .997 .100	.683 .692 -1.318	8
.915 .907 .874	.931 .924 .752	1.259 1.257 .159	1.212 1.202 .825	1.132 1.129 .265	.973 .976 -.308		9
1.125* 1.115 .889	.992 .989 .302	1.212 1.203 .743	1.107 1.103 .361	1.087 1.098 -1.012	.419 .421 -.477		10
.986 .990 .406	1.265 1.272 .553	1.132 1.128 .353	1.087 1.098 -.947	.785 .789 -.510			11
1.203 1.217 -1.164	.993 .993 0	.972 .975 -.309	.418 .421 -.718				12
.882 .896 -1.587	.680 .689 -1.323						13

NTP Assembly Power
LTP Assembly Power
$\frac{N-L}{N} \times 100$

* Mixed Oxide Assembly

	Peaking NTPXTG	LTPXTG
F_Q	1.59	1.60
$F_{\Delta H}$	1.42	1.43
F_Z	1.11	1.13

Figure 3.2 R. E. Ginna Cycle 12 Assembly Power Distribution, NTPXTG vs. LTPXTG Calculation, 1000 MWD/MT, HFP, ARO

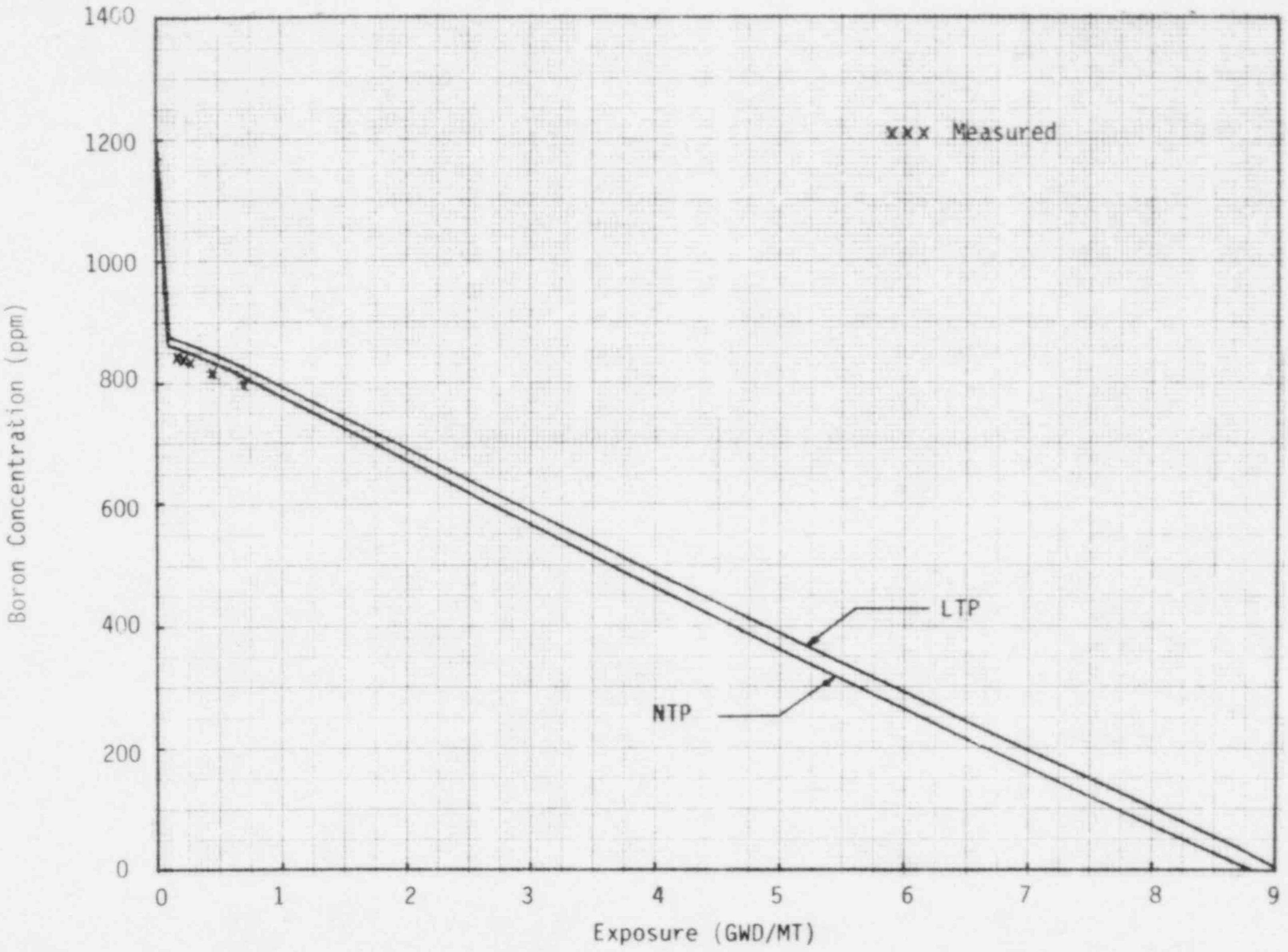

Figure 3.3 R. E. Ginna Cycle 12 Critical Boron vs. Exposure, ARO

4.0 GENERAL DESCRIPTION

The R. E. Ginna reactor consists of 121 assemblies, each having a 14x14 fuel rod array. Each assembly contains 179 fuel rods, 16 RCC guide tubes, and one (1) instrumentation tube. The fuel rods consist of slightly enriched UO_2 pellets inserted into zircaloy tubes. The RCC guide tubes and the instrumentation tube in Batches XN-2 and XN-3 are made of SS-304L. Composition of the RCC guide tubes and instrument tubes in Batches XN-4 and XN-5 are zircaloy. Each ENC assembly contains nine (9) zircaloy spacers with Inconel springs; eight (8) of the spacers are located within the active fuel region. Four (4) of the 121 assemblies contain mixed oxide (PuO_2 plus UO_2) bearing fuel rods. The MOX assemblies consist of three (3) enrichment zones of PuO_2 utilizing natural UO_2 as the diluent.

The Cycle 12 loading pattern is shown in Figure 4.1 with the assemblies identified by their Fabrication ID's and Region ID's. The initial enrichments of the various regions are listed in Table 4.1. BOC12 exposures, based on an EOC11 exposure of 7,100 MWD/MT, along with Region ID's are shown in Figure 4.2. The core consists of 12 fresh ENC XN-4 assemblies at 3.20 w/o U-235 with zircaloy guide tubes and twelve (12) fresh ENC XN-5 assemblies at 3.30 w/o U-235 with zircaloy guide tubes. A total of twenty four (24) fresh assemblies are loaded in Cycle 12. Remaining assemblies in the core consist of 93 exposed ENC assemblies and four (4) Westinghouse mixed oxide assemblies. The Cycle 12 core loading has eight (8) Region 11 (XN-2) and 24 fresh assemblies located on the core periphery. This loading pattern satisfies the Technical Specification criteria with respect to power peaking while maintaining an adequate shutdown margin.

Table 4.1 R. E. Ginna Cycle 12 Fuel Assembly Design Parameters

	Region						
	11	12	MOX	12	13	13	14
Enrichment, wt% U-235	3.200	3.450	2.626	3.45	3.20	3.20	3.30
Number of Assemblies	33	32	4	4	24	12	12
Pellet Density, %TD	94.0	94.0	95.0	94.0	94.0	94.0	94.0
Pellet-to-Clad Diametral Gap, Mil	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Fuel Stack Height, in.	142.0	142.0	141.4	142.0	142.0	142.0	142.0
Region Average Burnup at BOC12, MWD/MT	26,572	16,857	11,663	5,868	6,673	0	0
Nominal Assembly Weight, KgU	373.78	373.78	395.91**	373.78	373.78	373.78	373.78
Guide Tube Composition	SS304L	SS304L	SS304L	SS304L	Zr	Zr	Zr
Fuel Supplier	ENC	ENC	W	ENC	ENC	ENC	ENC

---

* Wt% Pu (Based on Assembly Average)

** In Kg HM

M	L	K	J	I	H	G	F	E	D	C	B	A	
					P30 13	P26 13	P34 * 13						1
			M16 11	Q08 14	N31 12	N05 12	N30 12	Q04 14	M37 11				2
		Q10 14	P07 13	N23 12	P15 13	M26 11	P12 13	N22 12	P04 13	Q12 14			3
	M38 11	P02 13	N09 12	N15 12	M09 11	NP3 MOX	M01 11	N03 12	N12 12	P06 13	M15 11		4
	Q02 14	N27 12	N04 12	P23 13	M17 11	M07 11	M36 11	P22 13	N14 12	N26 12	Q05 14		5
P35 13	N35 12	P14 13	M02 11	M33 11	N17 12	P20 13	N20 12	M20 11	M12 11	P10 13	N34 12	P32 13	6
P28 13	N07 12	M27 11	NP4 MOX	M08 11	P18 13	M29 11	P21 13	M06 11	NP2 MOX	M25 11	N08 12	P27 13	7
P31 13	N36 12	P09 13	M10 11	M18 11	N18 12	P19 13	N19 12	M35 11	M04 11	P13 13	N33 12	P36 13	8
	Q06 14	N28 12	N16 12	P17 13	M34 11	M05 11	M19 11	P24 13	N02 12	N25 12	Q01 14		9
	M13 11	P05 13	N10 12	N01 12	M03 11	NP1 MOX	M11 11	N13 12	N11 12	P01 13	M40 11		10
		Q11 14	P03 13	N24 12	P11 13	M28 11	P16 13	N21 12	P08 13	Q09 14			11
			M39 11	Q03 14	N32 12	N06 12	N29 12	Q07 14	M14 11				12
					P33 13	P25 13	P29 13	Assembly ID Region**					13

* ENC Reload Fuel by Fractions IDXXX

** See Table 4.1 for Region Definitions

Figure 4.1 R. E. Ginna Cycle 12 Loading Pattern

G	F	E	D	C	B	A	
29,470 11	8,862 13	25,988 11	11,663 MOX	27,132 11	4,817 12	0.0 13	7
7,710 13	16,558 12	26,785 11	24,397 11	7,054 13	18,506 12	0.0 13	8
25,966 11	26,787 11	8,297 13	14,357 12	16,170 12	0.0 14		9
11,664 MOX	24,379 11	14,356 12	20,254 12	4,670 13	28,184 11		10
27,155 11	7,058 13	16,158 12	4,669 13	0.0 14			11
6,920 12	18,499 12	0.0 14	28,195 11				12
0.0 13	0.0 13						13

BOC12 Exposure, MWD/MT
Region ID

Figure 4.2 R. E. Ginna BOC12 Quarter Core Exposure Distribution and Region ID

5.0 FUEL SYSTEM DESIGN

The previous R. E. Ginna fuel supplied by Exxon are described in references 13, 14 and 15. The first three reloads used stainless steel guide tubes, and the fourth reload used Zircaloy-4 guide tubes. By using as-built dimensions and actual operating history power cycles, the burnup of this fuel was extended to 40,000 MWD/MT.

The fifth and sixth ENC reloads for R. E. Ginna are a high burnup design which allows the peak assembly to reach 42,000 MWD/MT. The design report describing the mechanical analyses is given in reference 16.

5.1 FUEL DESCRIPTION

The XN-5 and XN-6 reloads (Cycles 12 and 13) are very similar in design to the XN-4 reload. Table 5.1 gives a comparison of the XN-4, XN-5, and XN-6 reloads. The basic dimensions and design are the same. The differences that allow Batches XN-5 and XN-6 to go to higher burnups include:

- o Control of the cladding contractile strain ratio
- o Smoother cladding ID surface
- o Resinter restrictions on the fuel.

5.2 DESIGN CRITERIA

Reference 16 gives the mechanical design criteria and the analysis results. The criteria were satisfied for a peak assembly average exposure of 42,000 MWD/MTU and for a peak rod average exposure of 45,000 MWD/MTU. Table 5.3 gives the power history used for the mechanical design.

Table 5.1 R. E. Ginna Fuel Mechanical Design

Fuel Rod	XN-4	XN-5, XN-6
Fuel Material	UO_2 Sintered Pellets	UO_2 Sintered Pellets
Fuel Enrichment, w/o	3.20	3.30, 3.45
Pellet Diameter, (in)	0.3565	0.3565
Dish Volume Per Pellet, (Total %)	1.0	1.0
Pellet Density, (% TD)	94.0	94.0
Cladding Material	Zircaloy-4	Zircaloy-4
Cladding ID, (in)	0.364	0.364
Cladding OD, (in)(14)	0.424	0.424
Diametral Gap, Cold Nominal, (in)	0.0075	0.0075
Active Length, (in)	142.0	142.0
Total Rod Length, (in)	149.10	149.10
Number of Active Fuel Rods per UO_2 Bundle	179	179
Fuel Rod Array, Square	14x14	14x14
Fuel Rod Pitch, (in)	0.556	0.556
Spacer Type	Zircaloy-4 with 718 Inconel Springs	Zircaloy-4 with 718 Inconel Springs
Number Per Assembly	9	9
Number Within Active Fuel	8	8
Control Rod Guide Tube Material	Zircaloy-4	Zircaloy-4

Table 5.1 (Continued)

Fuel Assembly	XN-4	XN-5, XN-6
Control Rod Guide Tube Dimensions (Upper), (in)	0.541 OD x 0.507 ID	0.541 OD x 0.507 ID
Control Rod Guide Tube Dimensions (Lower), (in)		
First Step	0.479 OD x 0.445 ID	0.479 OD x 0.445 ID
Second Step	0.475 OD x 0.441 ID	0.475 OD x 0.441 ID
Instrumentation Tube Material	Zircaloy-4	Zircaloy-4
Instrumentation Tube Dimensions, (in)	0.424 OD x 0.346 ID	0.424 OD x 0.346 ID
Spacer Outside Dimensions, (in)	7.763 x 7.763	7.763 x 7.763
Fuel Assembly Pitch, (in)	7.803 x 7.803	7.803 x 7.803
Length Between Tie Plates, (in)	150.665	150.665
Total Assembly Length, (in)	160.130	160.130

Table 5.2 R. E. Ginna Exposure and Flux History For The Pin With Maximum Discharge Exposure

Cycle	Cycle Exposure GWD/MT	Irradiation Time EFPH	Cumulative Assy. Exp. GWD/MT	Cumulative Peak Pin Exposure GWD/MT	Pin LHGR kw/ft	Pin Flux > 1 MeV $10^{13} n/cm^2$ sec
12	0	0	0	0	8.64	7.92
	1	716	1.133	1.438	8.44	7.81
	2	1431	2.261	2.863	8.43	7.83
	4	2862	4.521	5.713	8.35	7.83
	6	4293	6.778	8.535	8.24	7.79
	8	5724	9.019	11.320	8.15	7.77
	8.8	6296	9.909	12.421	8.12	7.76
	9.2	6583	10.354	12.971	8.11	7.76
13	0	0	10.354	12.971	7.63	8.18
	1	716	11.568	14.252	7.56	8.12
	2	1431	12.778	15.530	7.54	8.12
	4	2862	15.194	18.080	7.51	8.11
	6	4293	17.595	20.617	7.46	8.08
	8	5724	19.983	23.137	7.42	8.06
	9.2	6583	21.407	24.642	7.39	8.04
14	0	0	21.407	24.642	6.93	8.26
	1	716	22.683	25.831	7.06	8.41
	2	1431	23.841	27.022	6.98	8.32
	4	2862	26.131	29.380	6.89	8.21
	6	4293	28.392	31.709	6.87	8.19
	8	5724	30.648	34.032	6.87	8.18
	9.2	6583	32.000	35.426	6.86	8.17
15	0	0	32.000	35.426	5.61	7.48
	1	716	32.977	36.395	5.79	7.67
	2	1431	33.961	37.372	5.77	7.64
	4	2862	35.923	39.319	5.77	7.62
	6	4293	37.887	41.267	5.82	7.65
	8	5724	39.866	43.230	5.87	7.68
	9.2	6583	41.019	44.400	5.90	7.69
	a	7298	41.983	45.377	5.79	7.67

6.0 NUCLEAR DESIGN

The neutronics characteristics of the Cycle 12 core are quite similar to those of the Cycle 11 core (see Section 6.1).

The nuclear design bases for the Cycle 12 core are as follows:

1. The design shall permit operation within the Technical Specifications for the R. E. Ginna plant.
2. The length of Cycle 12 shall be determined on the basis of an EOC11 length of 7,100 MWD/MT.
3. The Cycle 12 loading pattern shall be optimized to achieve power distributions and control rod reactivity worths according to the following constraints:
   a) The peak F_Q shall not exceed 2.32 and the peak $F_{\Delta H}$ shall not exceed 1.66 (including uncertainties) in any single fuel rod through the cycle under nominal full power operation conditions with either NTP or LTP conditions.
   b) The scram worth of all rods minus the most reactivity shall exceed the BOC and EOC shutdown requirements.
4. The Cycle 12 core shall have a negative power coefficient.

The neutronic design methods utilized to ensure the above requirements are consistent with those described in References 17, 18, and 19.

6.1 PHYSICS CHARACTERISTICS

The neutronic characteristics of the Cycle 12 core at LTP are compared with those of Cycle 11 and Cycle 12 at NTP in Table 6.1. The data presented in the table indicate the neutronic similarity between Cycle 11 and Cycle 12 at NTP and Cycle 12 at LTP. The Cycle 12 loading pattern is applicable for Cycle 12 operation at LTP and NTP and is based on the actual Cycle 11 shutdown burnup of 7,100 MWD/MT.

The calculated boron letdown curve for Cycle 12 at LTP is shown in Figure 6.1. The curve indicates a BOC12, no xenon, critical boron concentration of 1,198 ppm. At 100 MWD/MT, equilibrium xenon, the critical boron concentration is 873 ppm. The Cycle 12 length is projected to be 8,800±300 MWD/MT with 31 ppm of boron at EOC.

6.1.1 Power Distribution Considerations

Representative predicted power maps for Cycle 12 at LTP are shown in Figures 6.2 and 6.3 for BOC and EOC conditions, respectively. The power distributions were obtained from a three-dimensional core simulator model(20) with moderator density and Doppler feedback effects incorporated. For the projected Cycle 12 loading pattern at LTP the calculated BOC nuclear power peaking factors, F_Q^N, $F_{\Delta H}^N$, and F_Z^N, are 1.711, 1.436, and 1.195, respectively. At EOC conditions the corresponding values are 1.524, 1.370, and 1.104 respectively. The Technical Specification limits relative to F_Q^N and $F_{\Delta H}^N$, with the measurement uncertainties backed out, are 2.15, and 1.60, respectively. Additionally the predicted axial F_Q^N distributions are well below the axially dependent Technical Specification limits on F_Q. The BOC F_Q^N value of 1.711 compares with the measured Cycle 12 NTP value in Table 6.1 of 1.703.

The control of the core power distribution is accomplished by following the procedures as discussed in the report, XN-76-40, "Exxon Nuclear Power Distribution Control for Pressurized Water Reactors", September 1976 and its addendum. The results reported in these documents demonstrate that the Power Distribution Control (PDC) procedures defined in the report will protect an axially dependent F_Q limit with a peak value of 2.30. The Technical Specification limit for R. E. Ginna has a peak of 2.32 and an axially dependence identical to that supported by the procedures. The physics characteristics of the Ginna Cycle 12 core at LTP are similar to those utilized in the PDC supporting analysis. The Ginna Technical Specification limits on F_Q can therefore be protected by operation under the PDC procedures as stated in XN-76-40.

6.1.2 Control Rod Reactivity Requirements

Detailed calculations of shutdown margins for Cycle 12 at LTP are compared with Cycle 11 and Cycle 12 at NTP in Table 6.2. The ENC Plant Transient Simulation (PTS) Analysis indicates that the minimum required shutdown margin is 1600(4) pcm based upon the steamline break accident analyzed for ENC fuel at the EOC conditions. A value of 1,900 pcm is used at EOC in the evaluation of the shutdown margin to be consistent with the Technical Specifications. The Cycle 12 analysis at LTP indicates excess shutdown margins of 1,631 pcm at the BOC and 365 pcm at the EOC. The Cycle 12 NTP analysis(12) indicates excess shutdown margins for that cycle of 1,497 pcm at the BOC and 288 pcm at the EOC. The slightly higher Cycle 12 LTP excess shutdown margins, when compared to the Cycle 12 NTP values, are due to slightly lower changes in the power defect due to the difference in the conditions in the moderator.

The control rod groups and insertion limits for Cycle 12 will remain unchanged from Cycle 11. With these limits the nominal worth of the control bank, D-bank, inserted to the insertion limits at HFP is 211 pcm at BOC and 293 pcm at EOC. The control rod shutdown requirements in Table 6.2 allow for a HFP D-bank insertion equivalent to 300 pcm for both BOC and EOC.

6.1.3 Moderator Temperature Coefficient Considerations

The reference Cycle 12 design calculations indicate that the moderator temperature coefficient is negative at all times during Cycle 12 at LTP as shown in Table 6.1. This meets the Technical Specification requirement that the moderator temperature coefficient be negative at all times during power operation and the design criteria that the power coefficient be negative. The least negative moderator temperature coefficient occurs at BOC HZP and is -0.4 pcm/^{o}F. This compares with the BOC11 HZP value of -0.7 pcm/^{o}F.

6.2 ANALYTICAL METHODOLOGY

The methods used in the Cycle 12 core analyses at LTP are described in References 17, 18, and 19. These methods have been verified for both UO_2 and PuO_2-UO_2 lattices. In summary, the reference neutronic design analysis of the reload core was performed using the XTG (Reference 20) reactor simulator system. The input exposure data were based on quarter core depletion calculations performed from Cycle 5 to Cycle 11 using the XTG code. The BOC5 exposure distribution was obtained from plant data. The fuel shuffling between cycles was accounted for in the calculations.

Predicted values of F_Q, F_{xy}, and F_z were studied with the XTG reactor model. The calculational thermal-hydraulic feedback and axial exposure distribution effects on power shapes, rod worths, and cycle lifetime are explicitly included in the analysis.

Table 6.1 R. E. Ginna Neutronics Characteristics of Cycle 12
Compared with Cycle 11 Data

	Cycle 11		Cycle 12(5) NTP		Cycle 12 LTP	
	BOC	EOC	BOC	EOC	BOC	EOC
Critical Boron						
HFP, ARO, Eq. Xenon (ppm)	890(1)	20(1)	855(5)	0	873	31
HZP, ARO, No Xenon (ppm)	1,359(2)	-----	1,330(2)	-----	1,330(2)	-----
Moderator Temperature Coefficieint						
HFP, (pcm/°F)	-8.2(4)	-30.9(4)	-7.1	-27.3	-5.65	-24.81
HZP, (pcm/°F)	-0.7(2)	-24.5(4)	-0.3	-20.0	-.44	-20.41
Doppler Coefficient, (pcm/°F)	-1.39(4)	-1.62(4)	-1.35	-1.63	-1.40	-1.55
Boron Worth, (pcm/ppm)						
HFP	-8.2(4)	-8.8(4)	-7.8	-8.6	-7.9	-8.4
Total Nuclear Peaking Factor						
F_Q^N, HFP	1.750(3)	-----	1.703(2)	1.51	1.711	1.524
Delayed Neutron Fraction	.0059(6)	.0052(4)	.0059(5)	.0052	.0059	.0052
Control Rod Worth of All Rods In Minus Most Reactive Rod, HZP, (pcm)	5775(4)	5967(4)	5599	5811	5665	5769
Excess Shutdown Margin (pcm)	1720(4)	463(4)	1497	288	1631	365
Moderator Pressure Coefficient (pcm/psia)	.09	0.35	.09	0.35	.09	0.35

---

(1) Extrapolated From Measured Data
(2) Measured Data
(3) 100% Power Map 150 MWD/MT
(4) Reference 10
(5) Reference 21
(6) Startup Value

Table 6.2 R. E. Ginna Control Rod Shutdown Margins and Requirements for Cycle 12

	Cycle 11**		Cycle 12+ NTP		Cycle 12 LTP	
	BOC	EOC	BOC	EOC	BOC	EOC
Control Rod Worth (HZP), pcm						
All Rods Inserted (ARI)	6,675	6,922	6,387	6,705	6,476	6,667
ARI Less Most Reactivity (N-1)	5,775	5,967	5,599	5,811	5,665	5,769
N-1 Less 10% Allowance ((N-1)*.9)	5,197	5,370	5,039	5,230	5,098	5,192
Reactivity Insertion, pcm						
Moderator plus Doppler	1,527	2,057	1,592	2,092	1,517	1,977
Flux Redistribution	600	600	600	600	600	600
Void	50	50	50	50	50	50
Sum of The Above Three	2,177	2,707	2,242	2,742	2,167	2,627
Rod Insertion Allowance	300	300	300	300	300	300
Total Requirements	2,477	3,007	2,542	3,042	2,467	2,927
Shutdown Margin (N-1)*.9 - Total Requirements	2,720	2,363	2,497	2,188	2,631	2,265
Required Shutdown Margin*	1,000	1,900	1,000	1,900	1,000	1,900
Excess Shutdown Margin	1,720	463	1,497	288	1,631	365

---

* Technical Specification 3.10
** Calculated Values From Reference 10
\+ Calculated Values From Reference 12

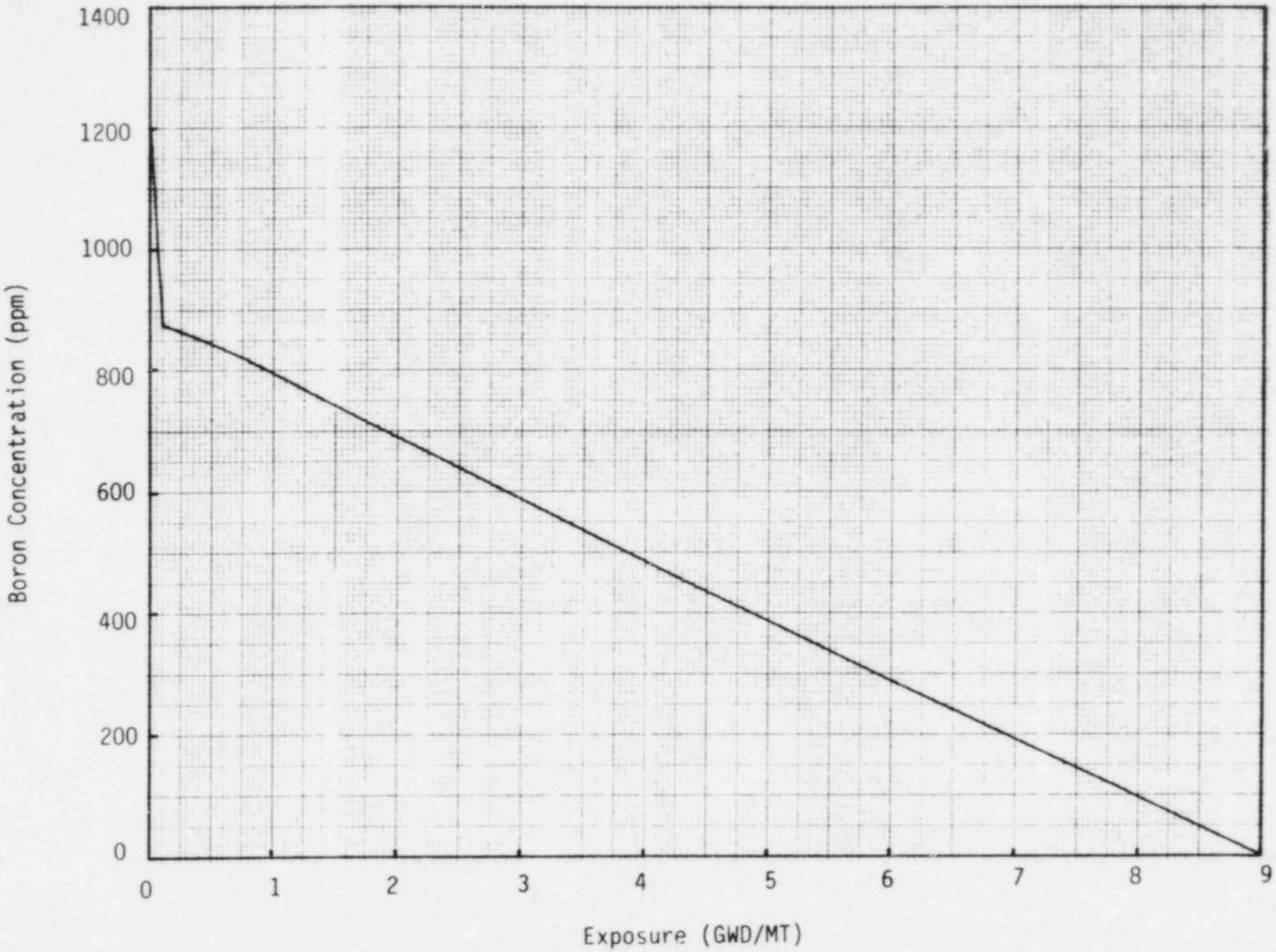

Figure 6.1 R. E. Ginna Cycle 12, Critical Boron vs. Exposure, LTP, ARO

G	F	E	D	C	B	A	
.932	1.177	.873	1.110*	.990	1.283	.929	7
1.194	1.069	.892	.973	1.289	1.013	.708	8
.874	.893	1.246	1.200	1.138	.996		9
1.109*	.974	1.201	1.104	1.107	.414		10
.988	1.286	1.138	1.107	.797			11
1.248	1.008	.994	.414				12
.926	.705						13

Assembly Power

* Mixed Oxide Assembly

Maximum Peaking

$F_Q^N = 1.711$

$F_{\Delta H} = 1.436$

$F_Z = 1.195$

Figure 6.2 R. E. Ginna XTG Assembly Relative Power, Cycle 12, LTP, 0 MWD/MT, ARO, HFP (EOC12 = 7,100 MWD/MT)

G	F	E	D	C	B	A	
1.003	1.212	.951	1.116*	.995	1.203	.909	7
1.225	1.121	.962	1.004	1.226	.996	.723	8
.952	.962	1.227	1.173	1.106	.972		9
1.116*	1.004	1.174	1.084	1.077	.456		10
.993	1.225	1.106	1.078	.801	Assembly Power		11
1.179	.993	.972	.456				12
.908	.721						13

* Mixed Oxide Assembly

$F_Q = 1.524$

$F_{\Delta H} = 1.370$

$F_Z = 1.104$

Figure 6.3 R. E. Ginna Cycle 12 XTG Depletion, LTP, HFP, 8,700 MWD/MT, 41 ppm

7.0 THERMAL HYDRAULIC DESIGN AND PERFORMANCE

The basic thermal hydraulic design analyses for ENC reload fuel at R. E. Ginna are reported in References 2, 3, and 4. These analyses are applicable to Cycle 12 in which ENC reload batch XN-5 will be placed in the core. Rod bow analyses for ENC fuel at R. E. Ginna were reported in the Cycle 11 SAR, XN-NF-81-01(10). The rod bow analyses considered peak assembly exposures of 41,000 MWD/MT. Current projections are that Batch XN-5 fuel may reach 42,000 MWD/MT. This is a small increase in burnup and is at an exposure when the fuel will be non-limiting due to fissile depletion. The increase in assembly exposure, 42,000 MWD/MT versus 41,000 MWD/MT, is sufficiently small that the MDNBR including rod bow penalty of 1.48 reported previously(10) for the limiting two (2) pump coastdown transient continues to apply.

The total nuclear peaking augmentation factor including rod bow is calculated to be 1.087 for an assembly exposure of 42,000 MWD/MT. The Ginna Technical Specifications allow a total nuclear peaking augmentation factor of 1.082 for calculation for the ECCS safety limits. This factor is adequate to accommodate nuclear augmentation due to rod bow in a limiting assembly with exposure up to 35,800 MWD/MTM as calculated, using the methodology of Reference 22. Fuel assemblies with exposures in excess of this value are anticipated to be operating well below the LOCA limits due to the reduction of assembly reactivity. Therefore, no additional penalty due to rod bow needs to be applied for calculation of LOCA limits.

8.0 ACCIDENT AND TRANSIENT ANALYSIS

8.1 ECCS ANALYSIS

ENC has reanalyzed the segment of the limiting large break (0.4 DECLG) calculation which is affected by the fan cooler capacity change for nominal primary coolant system temperature and pressure conditions (573.5^{O}F T_{avg} and 2,250 psia) and for reduced temperature and pressure conditions (527.5^{O}F T_{avg} and 2,000 psia). These calculated results are documented in XN-NF-82-26(6). The results show that the criteria specified by 10 CFR 50.46 are satisfied with this analysis which was performed in conformance with Appendix K of 10 CFR 50. This analysis supports operation of the R. E. Ginna plant with a peak Linear Heat Generation Rate (LHGR) of 13.76 kw/ft at a total peaking factor (F_Q^T) of 2.32 and at a rated power of 1,520 MWt with ENC fuel. These results are applicable over the range of primary coolant system fluid conditions of 2,000 to 2,250 psia pressure and 527.5^{O}F to 573.5^{O}F T_{avg}.

8.2 PLANT TRANSIENT ANALYSIS

The kinetics parameters for Cycle 12, which has ENC Reload Batch XN-5, are presented in Table 8.1. The kinetics parameters used in the plant transient analysis for reduced T_{avg} and pressure reported in Reference 4 are also presented in Table 8.1. The analyses showed that operation at LTP is less limiting for plant transient considerations than operation at normal conditions.

8.3 ROD EJECTION ANALYSIS FOR R. E. GINNA CYCLE 12

A Control Rod Ejection Accident is defined as the mechanical failure of a control rod mechanism pressure housing, resulting in the ejection of a Rod Cluster Control Assembly (RCCA) and drive shaft. The consequence of this mechanical failure is a rapid reactivity insertion together with an adverse core power distribution, possibly leading to localized fuel damage.

The rod ejection accident analysis presented in the document XN-NF-77-53(7) is still applicable to Cycle 12 operations. The Cycle 12 fuel assembly loading configuration introduces minimal effects on ejected rod worths and hot pellet peaking factors. The ejected rod worths and hot pellet peaking factors are calculated using the XTG code. No credit was taken for the power flattening effects of Doppler or moderator feedback in the calculation of ejected rod worths or peaking factors. The calculations made for Cycle 12 using XTG were two-dimensional (x-y) with appropriate axial buckling correction terms. The total peaking factors (F_Q^N) were determined as the product of the radial peaking factor (as calculated using XTG) and a conservative axial peaking factor. The pellet energy deposition resulting from an ejected rod was evaluated using the "Generic Analysis of the Control Rod Ejection Transition for PWR."(23) The rod ejection accident was found to result in energy deposition of less than 280 cal/gam stated in Regulatory Guide 1.77. The results of the control rod ejection transient for this case are presented in Table 8.2 along with the results from References 7, 10, 11, and 12.

Table 8.1 R. E. Ginna Unit 1 Kinetics Parameters

Parameters	Cycle 12 LTP Nominal Values		Values Used in Analysis		
	BOC	EOC	Rod Withdrawal And Loss of Load Transients, BOC	Loss of Primary Flow Transients, BOC	Steamline Break Transients From HZP, EOC
Moderator Temperature Coefficient, (pcm/°F)	-5.7	-24.8	0	0	**
Moderator Pressure Coefficient (pcm/psia)	+.09	+.35	0	0	*
Doppler Coefficient (pcm/°F)	-1.4	-1.6	-1.0	-1.5	***
Boron Worth Coefficient (pcm/ppm)	-7.9	-8.4	*	*	-7
Scram Worth (pcm)	-3467	-4827	-1600	-1600	*
Shutdown Margin (pcm)	1000	1900	*	*	-1600
Delayed Neutron Fraction	.0059	.0052	.0059	.0059	.0049

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* Not Applicable To This Transient

** See Figure 3.32 of Reference 4

*** See Figure 3.33 of Reference 4

Table 8.2 Ejected Rod Worth and Peaking Factors

	Cycle 8(2)		Cycle 11(3)		Cycle 12(3) NTP		Cycle 12(3) LTP	
	HFP	HZP	HFP	HZP	HFP	HZP	HFP	HZP
F_Q^N Before Ejection	2.25	2.82	2.21(1)	3.12(1)	2.28(1)	2.71(1)	2.30(1)	2.76(1)
F_Q^N After Ejection	4.36	5.30	2.88(1)	5.40(1)	3.00(1)	5.61(1)	3.11(1)	5.79(1)
Maximum Rod Worth From a Full Inserted Bank (%$\Delta\rho$)	0.470	0.640	0.302	0.467	0.313	0.502	0.345	0.510
Energy Deposition (cal/gm)	171	37	167(4)	29(4)	167(4)	28(4)	172(4)	30(4)

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(1) Includes a conservative estimate of F_Z at HFP of 1.4 and at HZP of 1.8.

(2) Reference 7, calculated with XTRAN.

(3) Calculated with XTGPWR.

(4) Reference 23, determined from the ENC generic analysis of the control rod ejection transient.

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