GE Nuclear Energy

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24A5412 Revision 1 Class I October 1997

24A5412, Rev. 1 Supplemental Reload Licensing Report for Branswick S. am Electric Plant Unit 2 Reload 12 Cycle 13

Approved

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Important Notice Regarding

Contents of This Report

Please Read Carefully

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Acknowledgement

The engineering and reload licensing analyses, which form the technical basis of this Supplemental Reload Licensing Report, were performed by G.M. Baka, H.J. Pearson and H.M. Schrum. The Supplemental Reload Licensing Report was prepared by G.M. Baka. This document has been verified by M.E. Harding.

The basis for this report is *General Electric Standard Application for Reactor Fuel*, NEDE-24011-P-A-13, August 1996; and the U.S. Supplement, NEDE-24011-P-A-13-US, August 1996.

1. Plant-unique Items

Appendix A:	Analysis Conditions
Appendix B:	Main Steamline Isolation Valve Out of Service (MSIVOOS)
Appendix C:	Decrease in Core Coolant Temperature Events
Appendix D:	Feedwater Temperature Reduction (FWTR)
Appendix E:	Maximum Extended Operating Domain (MEOD)

2. Reload Fuel Bundles

Fuel Type	Cycle Loaded	Numbe
Irradi.icd:		
GE10-P8HXB329-12GZ1-100M-150-T (GE8x8NB-3) GE10-P8HXB322-11GZ-70M-150-T (GE8x8NB-3) GE10-P8HXB320-11GZ-100M-150-T (GE8x8NB-3) GE10-P8HXB324-12GZ-70M-150-T (GE8x8NB-3) GE13-P9DTB363-11GZ1-100T-146-T (GE13) GE13-P9DTB363-11GZ-100T-146-T (GE13)	10 11 11 11 12 12	24 8 32 112 64 136
New:		
GE13-P9DTB393-4G6.0/9G5.0-100T-146-T (GE13) GE13-P9DTB395-12G5.0-100T-146-T (GE13)	13 13	104 80
Total		560

3. Reference Core Loading Pattern

Nominal previous cycle core average exposure at end of cycle:	27753 MWd/MT (25177 MWd/ST)
Minimum previous cycle core average exposure at end of cycle from cold shutdown considerations:	27381 MWd/MT (24840 MWd/ST)
Assumed reload cycle core average exposure at beginning of cycle:	15361 MWd/MT (13935 MWd/ST)
Assumed reload cycle core average exposure at end of cycle:	28148 MWd/MT (25535 MWd/ST)
Reference core loading pattern:	Figure 1

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Calculated Core Effective Multiplication and Control System Worth - No Voids, 20°C 4.

Beginning of Cycle, keffective	and the design of the low of the second
Uncontrolled	1.107
Fully controlled	0.964
Strongest control rod out	0.987
R, Maximum increase in cold core reactivity with exposure into cycle, Δk	0.000

5. Standby Liquid Control System Shutdown Capability

Boron	Shutdown Margin (Δk)
(ppm)	(20°C, Xenon Free)
660	0.038

Reload Unique GETAB Anticipated Operational Occurrences (AOO) Analysis 6. **Initial Condition Parameters**

posure: B	OC13 to E	OC13-220	5 MWd/	MT (2000 MV	Vd/ST) with	ICF	
	Peaking Factors						
Fuei Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE13	1.45	1.56	1.35	1.020	6.954	109.1	1.30

	Peaking Factors						PR No. and Construction of Automatic
Fuel Design	Local '	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE13	1.45	1.44	1.46	1.020	6.421	114.1	1.33

posure: E0	DC13-220	5 MWd/M	T (2000)	MWd/ST) to F	COC13 with	ICF and FWTR	
100.00	Pes	aking Fact	ors			T	
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE13	1.45	1.61	1.51	1.020	7.135	111.1	1.19

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	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE13	1.45	1.46	1.46	1.020	6.488	113.7	1.32

7. Selected Margin Improvement Options

Recirculation pump trip:	No
Rod withdrawal limiter:	No
Thermal power monitor:	Yes
Improved scram time:	Yes (ODYN Option B)
Measured scram time:	No
Exposure dependent limits:	Yes
Exposure points analyzed:	2 (EOC13-2205 MWd/MT and EOC13)

8. Operating Flexibility Options

Single-loop operation:	Yes
Load line limit:	Yes
Extended load line limit:	Yes
Maximum extended load line limit:	Yes
Increased core flow throughout cycle:	Yes
Flow point analyzed:	104.5 %
Increased core flow at EOC:	Yes
Feedwater temperature reduction throughout cycle:	Yes
Temperature reduction:	110.3°F
Final feedwater temperature reduction:	Yes
ARTS Program:	Yes
Maximum extended operating domain:	Yes

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		R	e	V		1	

Moisture separator reheater OOS:	No
Turbine bypass system OOS:	No
Safety/relief valves OOS: (credit taken for 9 of 11 valves)	Yes (Additional evaluations are required to support this option.)
ADS OOS:	Yes (2 valves OCS)
EOC RPT OOS:	No
Main steam isolation valves OOS:	Yes

9. Core-wide AOO Analysis Results

Methods used: GEMINI; GEXL-PLUS

Exposure range: BOC13 to EOC13-220	05 MWd/MT (2000 N	AWd/ST) w	ith ICF	
			Uncorrected $\triangle CPR$	
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
Load Reject w/o Bypass	272	114	0.21	2

Exposure range: EOC13-2205 MWd/N	1T (2000 MWd/ST) t	o EOC13 w	ith ICF	
			Uncorrected $\triangle CPR$	-
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
Load Reject w/o Bypass	335	120	0.24	3

Exposure range: EOC13-2205 MWd/M	Γ (2000 MWd/ST) t	o EOC13 w	ith ICF and FWTR	
			Uncorrected $\triangle CPR$	
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
FW Controller Failure ,	183	113	0.10	4

Exposure range: EOC13-2205 MWd/M	MT (2000 MWd/ST) t	o EOC13 w	ith MSIVOOS and IC	F
			Uncorrected $\triangle CPR$	
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
Load Reject w/o Bypass	291	118	0.23	5

10. Local Rod Withdrawal Error (With Limiting Instrument Failure) AOO Summary

The rod withdrawal error event in the maximum extended operating domain was originally analyzed in the GE BWR Licensing Report, Maximum Extended Operating Domain Analysis for Brunswick Steam Electric

Plant, NEDC-31654P, dated February 1989. The MCPR limit for rod withdrawal error is bounded by the operating limit MCPRs presented in Section 11 of this report for RBM setpoints shown in Tables 10–5(a) or 10–5(b) of NEDC-31654P. Additionally, the RBM operability requirements specified in Section 10.5 of NEDC-31654P have been evaluated and shown to be sufficient to ensure that the Safety Limit MCPR and cladding 1% plastic strain criteria will not be exceeded in the event of an un-blocked RWE event.

11. Cycle MCPR Values¹²

In agreement with commitments to the NRC (letter from M.A. Smith to Document Control Desk, *10CFR Part* 21, Reportable Condition, Safety Limit MCPR Evaluation, May 24, 1996) a cycle-specific Safety Limit MCPR calculation was performed and is reported in the Safety Limit MCPR shown below. CP&L, however, has elected to retain the current Technical Specification Safety Limit of 1.09 and the Operating Limit MCPR values shown below are based on this value. The cycle-specific single loop operation Safety Limit was calculated to be 0.01 greater than the two loop Safety Limit MCPR as shown below. This cycle specific SLMCPR was determined using the analysis basis documented in GESTAR with the following exceptions:

- 1. The reference core loading (Figure 1) was analyzed.
- 2. The actual bundle parameters (e.g., local peaking) were used.
- 3. The full cycle exposure range was analyzed.

Safety limit:	1.08 calculated	1.09 assumed
Single loop operation safety	limit: 1.09 calculated	1.10 assumed

Non-pressurization events:

Exposure Range: BOC13 to EOC13	
	GE13
Fuel Loading Error (misoriented)	1.29
Rod Withdrawal Error (for RBM setpoint of 108%)	1.25

Pressurization events:

Exposure range: BOC13 to EOC13-2205 M Exposure point: EOC13-2205 MWd/MT (20	Wd/MT (2000 MWd/ST) with ICF 000 MWd/ST)	
	Option A	Option B
	GE13	GE13
Load Reject w/o Bypass	1.35	1.30

^{1.} The Operating Limit MCPR for two loop operation (TLO) bounds the Operating Limit MCPR for single loop operation (SLO); therefore, the Operating Limit MCPR need not be changed for SLO.

 The ICF Operating Limits for the exposure range of BOC13 to EOC13-2205 MWd/MT (2000 MWd/ST) bound the Operating Limits for the following domains: MELLL, ICF and FWTR, MSIVOOS and ICF.

^{2.} The GE13 fuel type MCPR values bound the GE8x8NB-3 MCPR values for all events.

	Option A	Option B
	GE13	GE13
Load Reject w/o Bypass	1.43	1.35

Exposure range: EOC13-2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF and FWTP Exposure point: EOC13

	Option A	Option B
	GE13	GE13
FW Controller Failure	1.29	1.21

Exposure range: EOC13-2205 MWd/MT (2000 Exposure point: EOC13) MWd/ST) to EOC13 with MSI	VOOS and ICF
	Option A	Option B
	CIDIO	0540

	GEIS	GE15
Load Reject w/o Bypass	1.41	1.33
	An experimental sector in the sector is a subsective way to work a transmission which is in the sector is the sect	a subject of the same distant of the balance of the same distance of the same

12. Overpressurization Analysis Summary

Event	Psl	Pv	Plant
	(psig)	(psig)	Response
MSIV Closure (Flux Scram)	1286	1322	Figure 6

13. Loading Error Results

Variable water gap misoriented bundle analysis: Yes⁵

Misoriented Fuel Bundle	ΔCPR
GE13-P9DTB363-11GZ1-100T-146-T (GE13)	0.13
GE13-P9DTB363-11GZ-100T-146-T (GE13)	0.13
GE13-P9DTB395-12G5.0-100T-146-T (GE13)	0.19
GE13-P9DTB393-4G6.0/9G5.0-100T-146-T (GE13)	0.20

14. Control Rod Drop Analysis Results

This is a banked position withdrawal sequence plant, therefore, the control rod drop accident analysis is not required. NRC approval is documented in NEDE-24011-P-A-US.

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^{4.} The ICF Operating Limits for the exposure range of EOC13-2205 MWd/MT (2000 MWd/ST) to EOC13 bound the Operating Limits for the MELLL domain.

^{5.} Includes a 0.02 penalty due to variable water gap R-factor uncertainty.

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15. Stability Analysis Results

GE SIL-380 recommendations and GE interim corrective actions have been included in the Brunswick Steam Electric Plant Unit 2 operating procedures. Regions of restricted operation defined in Attachment 1 to NRC Bulletin No. 88-07, Supplement 1, Power Oscillations in Boiling Water Reactors (BWRs), are applicable to Brunswick 2.

16. Loss-of-Coolant Accident Results

LOCA method used: SAFER/GESTR-LOCA

The GE8x8EB LOCA analysis results presented in Sections 5 and 6 of Brunswick Steam Electric Plant Units 2 and 2 SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis, NEDC-31624P, Revision 2, July 1990, conservatively bound the LOCA analysis of the GE8x8NB-3 fuel types. This analysis yielded a licensing basis peak clad temperature of 1537°F, a peak local oxidation fraction of <0.31%, and a core-wide metal-water reaction of 0.036%.

An additional LOCA analysis was performed for the GE13 fuel type. The results, presented in *Brunswick* Steam Electric Plant Units 1 and 2 SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis: Application to GE13 Fuel, NEDC-31624P, Supplement 3, Rev. 0, January 1996, indicate that the GE13 fuel is bounded by the results from GE8x8EB fuel.

The most and the least limiting MAPLHGRs for the new GE13 fuel designs are as follows:

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16. Loss-of-Coolant Accident Results (cont)

Bundle 7	Type: GE	13-P9DTB395	5-12G5.0-1007	-146-T
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Average Planar Exposure		MAPLHGR(kW/ft)		
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting	
0.00	0.00	11.15	11.28	
0.20	C.22	11.24	11.34	
1.00	1.10	11.38	11.42	
2.00	2.20	11.50	11.53	
3.00	3.31	11.57	11.66	
4.00	4.41	11.66	11.75	
5.00	5.51	11.74	11.83	
6.00	6.61	11.83	11.92	
7.00	7.72	11.92	12.02	
8.00	8.82	12.02	12.11	
9.00	9.92	12.11	12.21	
10.00	11.02	12.21	12.31	
12.50	13.78	12.21	12.33	
15.00	16.53	12.04	12.13	
17.50	19.29	11.78	11.86	
20.00	22.05	11.51	11.59	
25.00	27.56	10.98	11.06	
30.00	33.07	10.44	10.53	
35.00	38.58	9.73	9.89	
40.00	44.09	9.03	9.18	
45.00	49.60	8.33	8.49	
50.00	55.12	7.64	7.82	
55.00	60.63	6.95	7.16	
58.32	64.28	6.49	6.70	
58.75	64.76		6.64	

16. Loss-of-Coolant Accident Results (cont)

Average Pla	Average Planar Exposure		R(kW/ft)		
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting		
0.00	0.00	11.03	11.09		
0.20	0.22	11.09	11.12		
1.00	1.10	11.19	11.21		
2.00	2.20	11.28	11.32		
3.00	3.31	11.37	11.42		
4.00	4.41	11.47	11.52		
5.00	5.51	11.57	11.63		
6.00	6.61	11.67	11.74		
7.00	7.72	11.78	11.85		
8.00	8.82	11.89	11.97		
9.00	9.92	12.00	12.09		
10.00	11.02	12.11	12.22		
12.50	13.78	12.12	12.25		
15.00	16.53	12.00	12.10		
17.50	19.29	11.76	11.84		
20.00	22.05	11.50	11.57		
25.00	27.56	10.96	11.04		
30.00	33.07	10.28	10.43		
35.00	38.58	9.54	9.71		
40.00	44.09	8.85	9.00		
45.00	49.60	8.19	8.31		
50.00	55.12	7.55	7.62		
55.00	60.63	6.92	6.93		
58.18	64.14	6.48	6.51		
58.60	64.60	ne for a second s	6.46		

Bundle Type: GE13-P9DTB393-4G6.0/9G5.0-100T-146-T



Fuel Type			
A=GE13-P9DTB363-11GZ1-100T-146-T	(Cycle 12)	E=GE13-P9DTB393-4G6.0/9G5.0-100T-146-T	(Cycle 13)
B=GE10-P8HXB322-11GZ-70M-150-T	(Cycle 11)	F=GE10-P8HXB320-11GZ-100M-150-T	(Cycle 11)
C=GE10-P8HXB329-12GZ1-100M-150-T	(Cycle 10)	G=GE10-P8HXB324-12GZ-70M-150-T	(Cycle 11)
D=GE13-P9DTB395-12G5.0-100T-146-T	(Cycle 13)	H=GE13-P9DTB363-11GZ-100T-146-T	(Cycle 12)

Figure 1 Reference Core Loading Pattern

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Figure 2 Plant Response to Load Reject w/o Bypass (BOC13 to EOC13-2205 MWd/MT (2000 MWd/ST) with ICF)

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Figure 3 Plant Response to Load Reject w/o Bypass (EOC13-2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF)



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Figure 4 Plant Response to FW Controller Failure (EOC13-2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF and FWTR)

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Figure 5 Plant Response to Load Reject w/o Bypass (EOC13-2205 MWd/MT (2000 MWd/ST) to EOC13 with MSIVOOS and ICF)



Figure 6 Plant Response to MSIV Closure (Flux Scram)

Appendix A Analysis Conditions

This is the first reload core for Brunswick Unit 2 which will operate at an uprated power of 105% (2558 MWt). To reflect actual plant parameters accurately, the values shown in Table A-1 were used for this cycle.

Parameter	Analysis Value			
	ICF	ICF and FWTR	MSIVOOS and ICF	
Thermal power, MWt	2558.0	2558.0	2558.0	
Core flow, Mlb/hr	80.5	80.5	80.5	
Reactor pressure, psia	1060.9	1059.6	1060.9	
Inlet enthalpy, BTU/lb	530.7	519.4	530.7	
Non-fuel power fraction	0.037	0.037	0.037	
Steam flow analysis, Mlb/h.	11.09	9.67	11.09	
Dome pressure, psig	1030.0	1030.0	1045.0	
Turbine pressure, psig	969.0	984.2	941.6	
No. of Safety/Relief Valves	9	9	11	
Relief mode lowest setpoint, psig	1164.0	1164.0	1164.0	
Recirculation pump power source	on-site ⁶	on-site ⁶	on-site ⁶	
Turbine control valve mode of operation	Partial arc	Partial arc	Partial arc	

Table A-1

6. Bounds operation with off-site power source for reload licensing events for Cycle 13.

Appendix B Main Steamline Isolation Valve Out of Service (MSIVOOS)

Reference B-1 provided a basis for operation of Brunswick Steam Electric Plant (BSEP) with one Main Steamline Isolation Valve Out of Service (MSIVOOS) (three steamline operation) and all S/RVs in service. For this mode of operation in BSEP Unit 2 throughout Cycle 13, the MCPR limits presented in Section 11 of this report are bounding and should be applied when operating in the MSIVOOS mode at any time during the cycle. The peak steamline and peak vessel pressures for the limiting overpressurization event (MSIV closure with flux scram) were not calculated for the MSIVOOS mode of operation. In this mode of operation it is required that all S/RVs be operational versus the assumed 2 S/RVs OOS for the events evaluated during normal plant operation. Previous cycles analyses have shown that the MSIV closure with flux scram, evaluated in the MSIVOOS mode, has resulted in the peak vessel pressure being reduced by more than 25 pai, when compared to the same case evaluated with all (four) steamlines operational.

Reference

B-1. Main Steamline Isolation Valve Out of Service for the Brunswick Steam Electric Plant, EAS-117-0987, GE Nuclear Energy, April 1988.

Appendix C Decrease in Core Coolant Temperature Events

The Loss of Feedwater Heater (LFWH) event and the HPCI inadvertent start-up event are the only cold water injection AOOs checked on a cycle-by-cycle basis. A Cycle 11 analysis showed a LFWH Δ CPR of 0.13 and a Cycl 10 analysis showed a HPCI inadvertent start-up Δ CPR of 0.15. As was the case for Cycle 12 also, there is no reason why these events would be expected to be more severe for Cycle 13. The results of the AOOs presented in Section 11 of this report sufficiently bound the expected results of the LFWH and HPCI inadvertent start-up events, therefore these events were not analyzed for Cycle 13.

Appendix D Feedwater Temperature Reduction (FWTR)

Reference D-1 provides the basis for operation of the Brunswick Steam Electric Plant with FWTR. The MCPR limits presented in Section 11 of this report are bounding and should be applied when operating with FWTR. Previous analysis has shown the FWCF event is most severe at ICF and FWTR.

Reference

D-1. Feedwater Temperature Reduction with Maximum Extended Load Line Limit and Increased Core Flow for Brunswick Steam Electric Plant Units 1 and 2, NEDC-32457P, Revision 1, December 1995.

Appendix E Maximum Extended Operating Domain (MEOD)

Reference E-1 provided a basis for operation of the Brunswick Steam Electric Plant in the Maximum Extended Operating Domain (MEOD). The reload licensing analysis performed for Cycle 13 and documented herein is consistent with and provides the cycle-specific update to the reference E-1 analysis. Application of the GEXL-PLUS correlation to the reload fuel has been confirmed as required in reference E-1. The applicability of GE13 was addressed and found acceptable.

Reference

E-1. Maximum Extended Operating Domain Analysis for Brunswick Steam Electric Plant, NEDC-31654P, GE Nuclear Energy (Proprietary), February 1989.

ENCLOSURE 3

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2 DOCKET NO. 50-324 LICENSE NO. DPR-62 TRANSMITTAL OF CORE OPERATING LIMITS REPORT, SUPPLEMENTAL RELOAD LICENSING REPORT, AND LOSS-OF-COOLANT-ACCIDENT ANALYSIS REPORT

NEDC-31624P, SUPPLEMENT 2, REVISION 4 LOSS-OF-COOLANT ACCIDENT ANALYSIS REPORT FOR BRUNSWICK STEAM ELECTRIC PLANT UNIT 2 RELOAD 12 CYCLE 13