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Supplemental Reload Licensing Report

for

Brunswick Steam Electric Plant Unit 2

Reload 10 Cycle 11

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Important Notice Regarding

Contents of This Report

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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 R.N. Anderson and M.R. Morris. The Supplemental Reload Licensing Report was prepared by R.N. Anderson. This document has been verified by F.T. Bolger.

The basis for this report is *General Electric Standard Application for Reactor Fuel*, NEDE–24011–P–A–10, February 1991; and the U.S. Supplement, NEDE–24011–P–A–10–US, March 1991.

1. Plant–unique Items

Appendix A: Analysis Conditions
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2. Reload Fuel Bundles

Fuel Type	Cycle Loaded	Number
Irradiated:		
GE8B–P8DQB323–11GZ–80M–4WR–150–T (GE8x8EB)	8	40
GE8B–P8DQB317–9GZ–80M–4WR–150–T (GE8x8EB)	8	52
GE9B–P8DWB330–11GZ–80M–150–T (GE8x8NB)	9	44
GE9B–P8DWB329–11GZ–80M–150–T (GE8x8NB)	9	124
GE10–P8HXB329–12GZ1–100M–150–T (GE8x8NB–3)	10	148
New:		
GE10–P8HXB324–12GZ–70M–150–T (GE8x8NB–3)	11	112
GE10–P8HXB320–11GZ–100M–150–T (GE8x8NB–3)	11	32
GE10–P8HXB322–11GZ–70M–150–T (GE8x8NB–3)	11	8
Total		560

3. Reference Core Loading Pattern

Nominal previous cycle core average exposure at end of cycle:	24027 MWd/MT (21797 MWd/ST)
Minimum previous cycle core average exposure at end of cycle from cold shutdown considerations:	24027 MWd/MT (21797 MWd/ST)
Assumed reload cycle core average exposure at beginning of cycle:	14713 MWd/MT (13348 MWd/ST)
Assumed reload cycle core average exposure at end of cycle:	26013 MWd/MT (23599 MWd/ST)
Reference core loading pattern:	Figure 1

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

Beginning of Cycle, $k_{effective}$	
Uncontrolled	1.102
Fully controlled	0.957
Strongest control rod out	0.988
R, Maximum increase in cold core reactivity with exposure into cycle, Δk	0.000

5. Standby Liquid Control System Shutdown Capability

Boron (ppm)	Shutdown Margin (Δk) (20°C, Xenon Free)
600	0.036

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

Exposure: BOC11 to EOC11–3000 MWd/MT (2722 MWd/ST) with ICF							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R–Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE8x8NB–3	1.20	1.69	1.40	1.000	7.158	112.1	1.23
GE8x8NB	1.20	1.67	1.40	1.000	7.107	111.3	1.24
GE8x8EB	1.20	1.59	1.40	1.051	6.737	118.3	1.23

Exposure: EOC11–3000 MWd/MT (2722 MWd/ST) to EOC11 with ICF							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R–Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE8x8NB–3	1.20	1.62	1.40	1.000	6.887	113.7	1.29
GE8x8NB	1.20	1.62	1.40	1.000	6.860	112.7	1.29
GE8x8EB	1.20	1.53	1.40	1.051	6.508	119.6	1.27

Exposure: BOC11 to EOC11 with MSIVOOS and ICF							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R–Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE8x8NB–3	1.20	1.63	1.40	1.000	6.918	113.5	1.28
GE8x8NB	1.20	1.62	1.40	1.000	6.890	112.5	1.28
GE8x8EB	1.20	1.54	1.40	1.051	6.530	119.4	1.27

7. Selected Margin Improvement Options

Recirculation pump trip:	No
Thermal power monitor:	Yes
Improved scram time:	Yes (ODYN Option B)
Measured scram time:	No
Exposure points analyzed:	2 (EOC11–3000 MWd/MT and EOC11)

8. Operating Flexibility Options

Single–loop operation:	Yes
Load line limit:	Yes
Extended load line limit:	Yes
Maximum extended load line limit:	Yes
Flow point analyzed:	105.0 %
Increased core flow at EOC:	Yes
Increased core flow throughout cycle:	Yes
ARTS Program:	Yes
Maximum extended operating domain:	Yes
Turbine bypass system OOS:	No
Safety/relief valves OOS: (credit taken for 9 of 11 valves)	Yes
ADS OOS:	Yes (2 valves OOS)
EOC RPT OOS:	No
Main steam isolation valve OOS:	Yes

9. Core–wide AOO Analysis Results

Methods used: GEMINI; GEXL–PLUS

Exposure range: BOC11 to EOC11–3000 MWd/MT (2722 MWd/ST) with ICF						
			Uncorrected ΔCPR			
Event	Flux (%NBR)	Q/A (%NBR)	GE8x8NB–3	GE8x8NB	GE8x8EB	Fig.
Load Reject w/o Bypass	373	119	0.17	0.17	0.16	2

Exposure range: EOC11–3000 MWd/MT (2722 MWd/ST) to EOC11 with ICF						
			Uncorrected ΔCPR			
Event	Flux (%NBR)	Q/A (%NBR)	GE8x8NB–3	GE8x8NB	GE8x8EB	Fig.
Load Reject w/o Bypass	423	123	0.22	0.22	0.21	3

Exposure range: BOC11 to EOC11 with MSIVOOS and ICF						
			Uncorrected ΔCPR			
Event	Flux (%NBR)	Q/A (%NBR)	GE8x8NB–3	GE8x8NB	GE8x8EB	Fig.
Load Reject w/o Bypass	378	123	0.21	0.21	0.20	4

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.

11. Cycle MCPR Values

Safety limit: 1.07

Single loop operation safety limit: 1.08[1]

Non–pressurization events:

Exposure range: BOC11 to EOC11			
	GE8x8NB–3	GE8x8NB	GE8x8EB
Fuel Loading Error: GE10–P8HXB324–12GZ–70M–150–T	1.31	—	—
GE10–P8HXB329–12GZ1–100M–150–T/ GE10–P8HXB322–11GZ–70M–150–T/ GE10–P8HXB320–11GZ–100M–150–T	1.25		
LFWH	1.20	1.20	1.20

Pressurization events:

Exposure range: BOC11 to EOC11–3000 MWd/MT (2722 MWd/ST) with ICF Exposure point: EOC11–3000 MWd/MT (2722 MWd/ST)						
	Option A			Option B		
	GE8x8NB–3	GE8x8NB	GE8x8EB	GE8x8NB–3	GE8x8NB	GE8x8EB
Load Reject w/o Bypass	1.34	1.34	1.33	1.27	1.27	1.26

Exposure range: EOC11–3000 MWd/MT (2722 MWd/ST) to EOC11 with ICF Exposure point: EOC11						
	Option A			Option B		
	GE8x8NB–3	GE8x8NB	GE8x8EB	GE8x8NB–3	GE8x8NB	GE8x8EB
Load Reject w/o Bypass	1.35	1.35	1.33	1.31	1.31	1.29

Exposure range: BOC11 to EOC11 with MSIVOOS and ICF Exposure point: EOC11						
	Option A			Option B		
	GE8x8NB–3	GE8x8NB	GE8x8EB	GE8x8NB–3	GE8x8NB	GE8x8EB
Load Reject w/o Bypass	1.34	1.34	1.32	1.30	1.30	1.28

1. Brunswick Steam Electric Plant units 1 and 2 Single Loop Operation, NEDC–31776P, December 1989, Operating limit MCPR for two loop operation (TLO) bounds the operating limit MCPR for single loop operation (SLO): $\Delta CPR(SLO) < (\Delta CPR(TLO) - 0.01)$, therefore,operating limit MCPR need not be changed for SLO.

12. Overpressurization Analysis Summary

Event	Psl (psig)	Pv (psig)	Plant Response
MSIV Closure (Flux Scram)	1252	1284	Figure 5

13. Loading Error Results[2]

Vaiable water gap misoriented bundle analysis: Yes

Misoriented fuel bundle	Δ CPR
GE10–P8HXB322–11GZ–70M–150–T(GE8X8NB–3)	0.12
GE10–P8HXB320–11GZ–100M–150–T(GE8X8NB–3)	0.13
GE10–P8HXB324–12GZ–70M–150–T(GE8X8NB–3)	0.24
GE10–P8HXB329–12GZ1–100M–150–T(GE8X8NB–3)	0.18

14. Control Rod Drop Analysis Results

Brunswick Steam Electric Plant Unit 2 is a group notch plant operating in the banked position withdrawal sequence, therefore, the control rod drop accident analysis is not required. NRC approval is documented in NEDE–24011–P–A–US.

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 are applicable to Brunswick 2 Reload 10 Cycle 11.

16. Loss–of–Coolant Accident Results

LOCA method used: SAFER/GESTR–LOCA

Reference: Brunswick Steam Electric Plant Units 1 and 2 SAFER/GESTR–LOCA Loss–of–Coolant Accident Analysis, NEDC–31624P, Rev. 2, July 1990.

The GE8x8EB LOCA analysis results presented in Sections 5 and 6 of NEDC–31624P 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%. The most limiting and the least limiting MAPLHGRs for the GE8x8NB–3 fuel designs are as follows:

2. ΔCPR penalty of 0.02 for the tilted misoriented bundle has been applied.

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

Bundle Type: GE10–P8HXB322–11GZ–70M–150–T (GE8x8NB–3)

Average Planar Exposure		MAPLHGR(kw/ft)	
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting
0.00	0.00	10.84	11.92
0.20	0.22	10.88	11.98
1.00	1.10	10.95	12.04
2.00	2.20	11.08	12.14
3.00	3.31	11.21	12.25
4.00	4.41	11.35	12.39
5.00	5.51	11.50	12.53
6.00	6.61	11.67	12.68
7.00	7.72	11.92	12.74
8.00	8.82	12.26	12.88
9.00	9.92	12.61	13.11
10.00	11.02	12.95	13.23
12.50	13.78	13.12	13.27
15.00	16.53	12.89	12.95
20.00	22.05	12.29	12.38
25.00	27.56	11.67	11.85
35.00	38.58	10.26	10.47
45.00	49.60	8.78	9.04
50.86	56.06	5.87	6.23
51.71	57.00	—	5.82

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

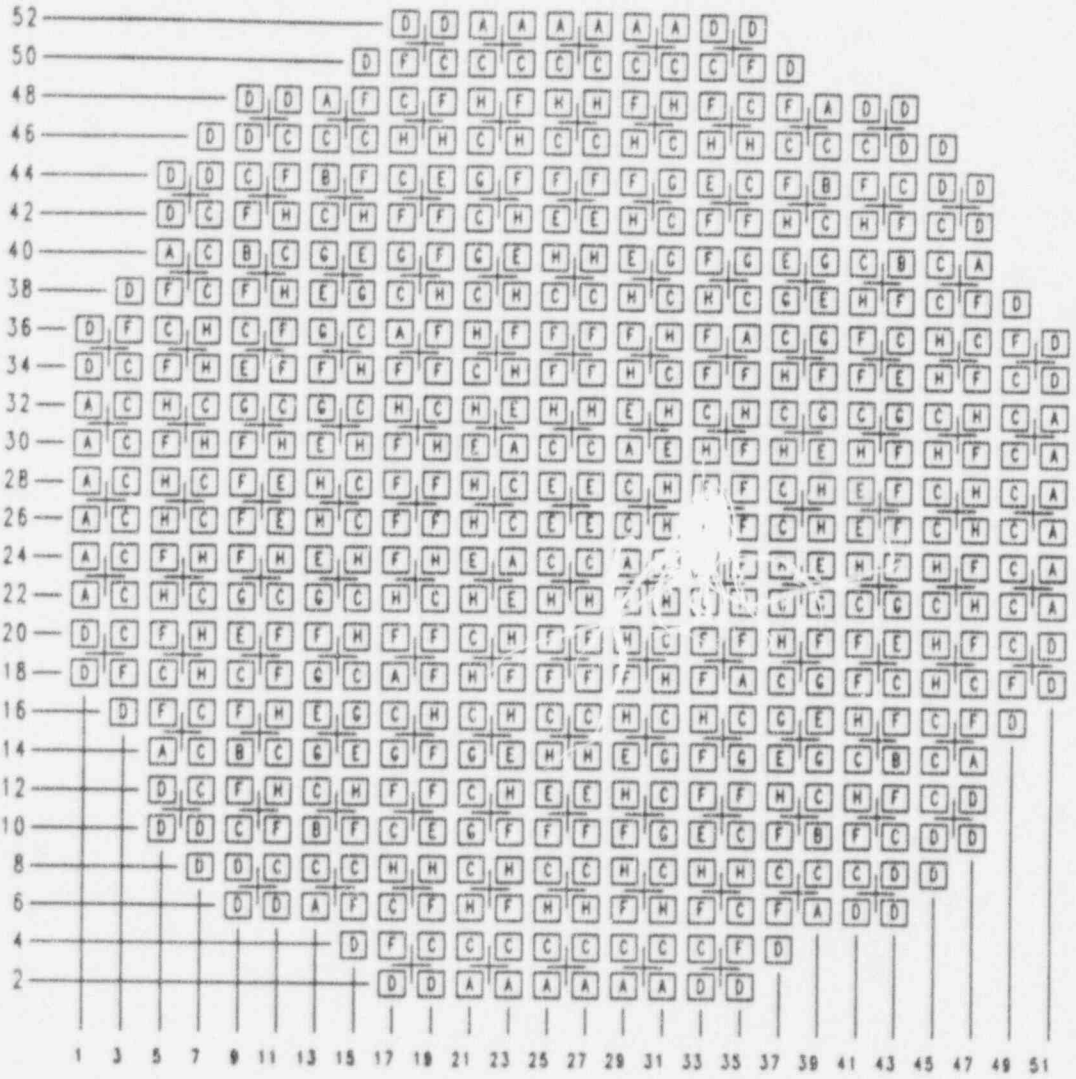
Bundle Type: GE10–P8HXB320–11GZ–100M–150–T (GE8x8NB–3)

Average Planar Exposure		MAPLHGR(kw/ft)	
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting
0.00	0.00	10.81	11.71
0.20	0.22	10.87	11.74
1.00	1.10	10.97	11.82
2.00	2.20	11.10	11.93
3.00	3.31	11.24	12.05
4.00	4.41	11.39	12.17
5.00	5.51	11.53	12.30
6.00	6.61	11.68	12.44
7.00	7.72	11.84	12.57
8.00	8.82	12.00	12.72
9.00	9.92	12.16	12.86
10.00	11.02	12.33	13.00
12.50	13.78	12.52	13.19
15.00	16.53	12.40	12.92
20.00	22.05	11.93	12.28
25.00	27.56	11.44	11.66
35.00	38.58	10.26	10.26
45.00	49.60	8.68	8.77
50.49	55.66	5.91	6.05
50.86	56.06	—	5.87

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

Bundle Type: GE10–P8HXB324–12GZ–70M–150–T (GE8x8NB–3)

Average Planar Exposure		MAPLHGR(kw/ft)	
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting
0.00	0.00	10.75	11.79
0.20	0.22	10.78	11.85
1.00	1.10	10.87	11.94
2.00	2.20	11.07	12.08
3.00	3.31	11.32	12.23
4.00	4.41	11.62	12.39
5.00	5.51	11.83	12.56
6.00	6.61	12.02	12.72
7.00	7.72	12.22	12.91
8.00	8.82	12.44	13.13
9.00	9.92	12.70	13.12
10.00	11.02	12.96	13.19
12.50	13.78	13.17	13.28
15.00	16.53	12.93	12.95
20.00	22.05	12.27	12.42
25.00	27.56	11.62	11.89
35.00	38.58	10.27	10.49
45.00	49.60	8.78	9.06
50.66	55.84	5.94	6.26
51.64	56.92	—	5.78



Fuel Type	
A=GE8B–P8DQB323–11GZ–80M–4WR–150–T	E=GE9B–P8DWB330–11GZ–80M–150–T
B=GE10–P8HXB322–11GZ–70M–150–T	F=GE9B–P8DWB329–11GZ–80M–150–T
C=GE10–P8HXB329–12GZ1–100M–150–T	G=GE10–P8HXB320–11GZ–100M–150–T
D=GE8B–P8DQB317–9GZ–80M–4WR–150–T	H=GE10–P8HXB324–12GZ–70M–150–T

Figure 1 Reference Core Loading Pattern

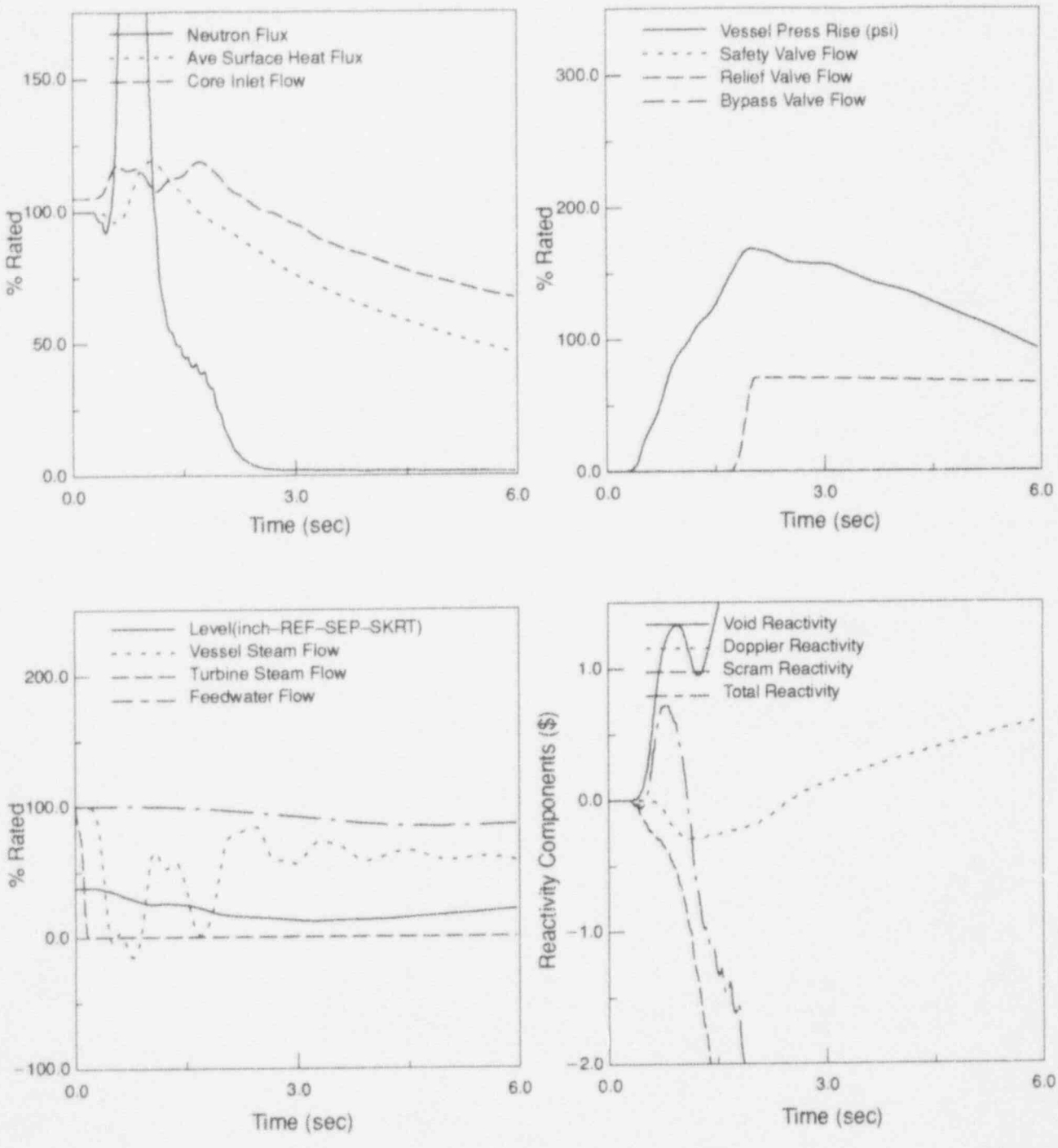


Figure 2 Plant Response to Load Reject w/o Bypass (BOC11 to EOC11–3000 MWd/MT (2722 MWd/ST) with ICF)

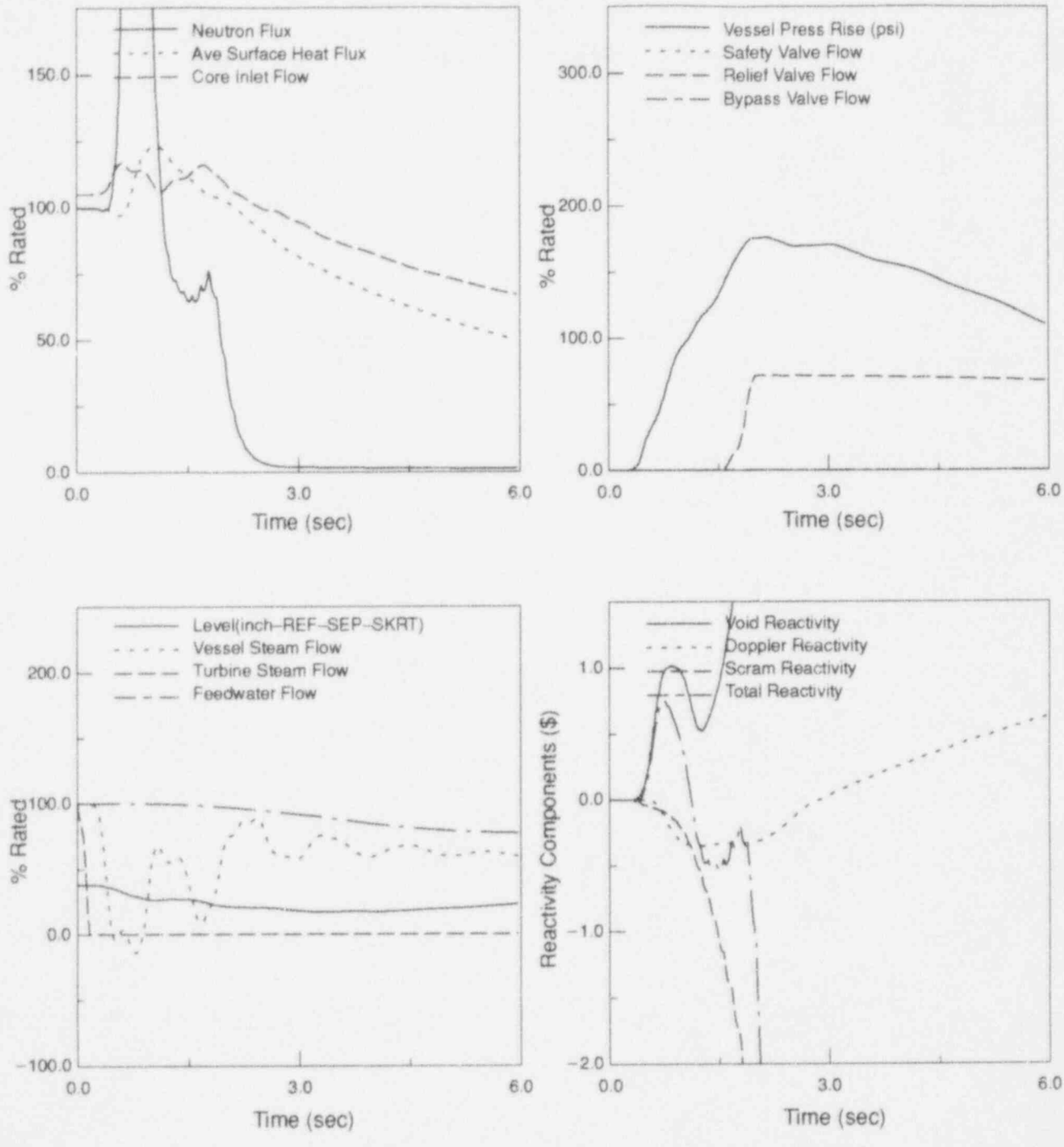


Figure 3 Plant Response to Load Reject w/o Bypass (EOC11–3000 MWd/MT (2722 MWd/ST) to EOC11 with ICF)

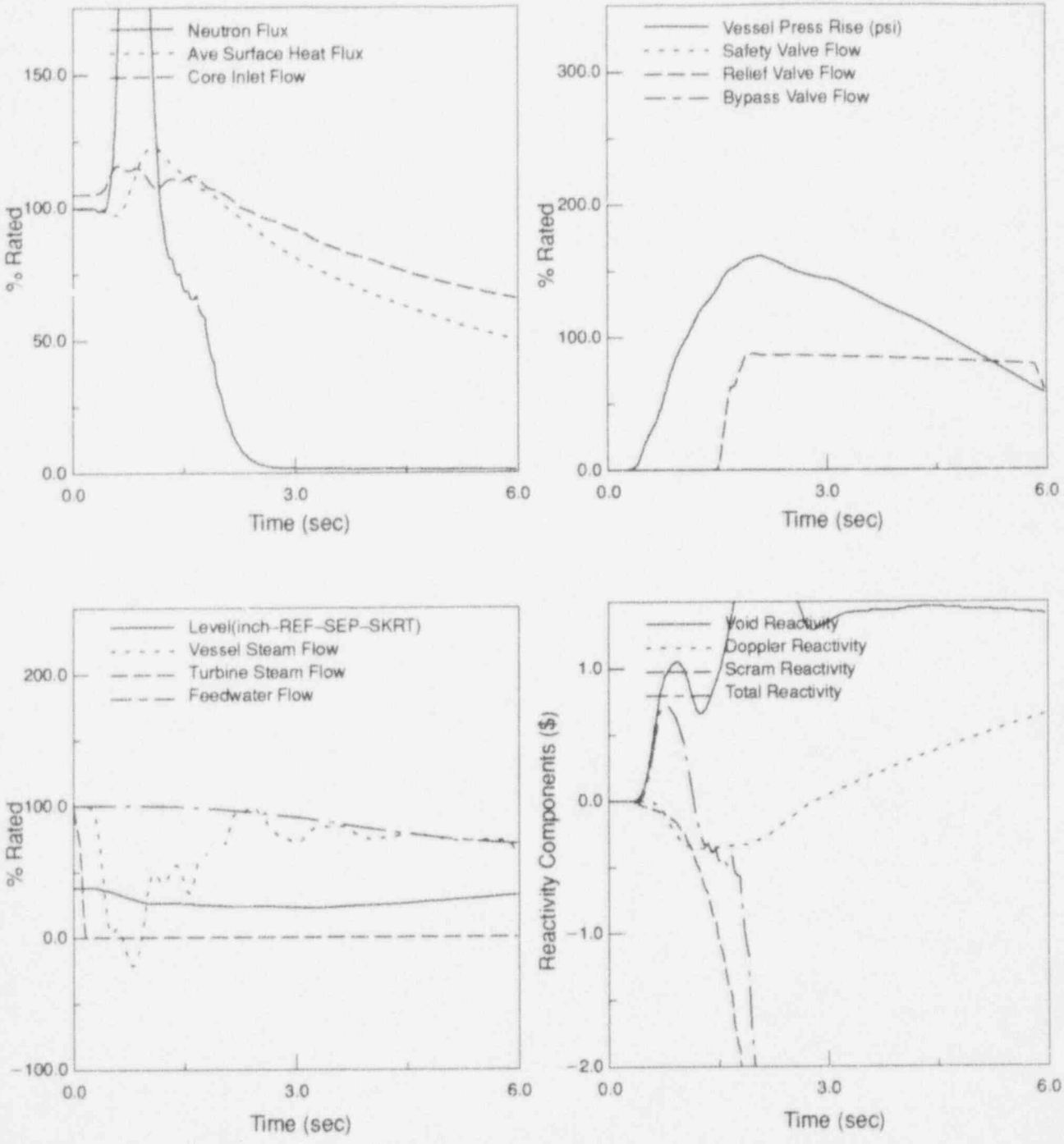


Figure 4 Plant Response to Load Reject w/o Bypass (BOC11 to EOC11 with MSIVOOS and ICF)

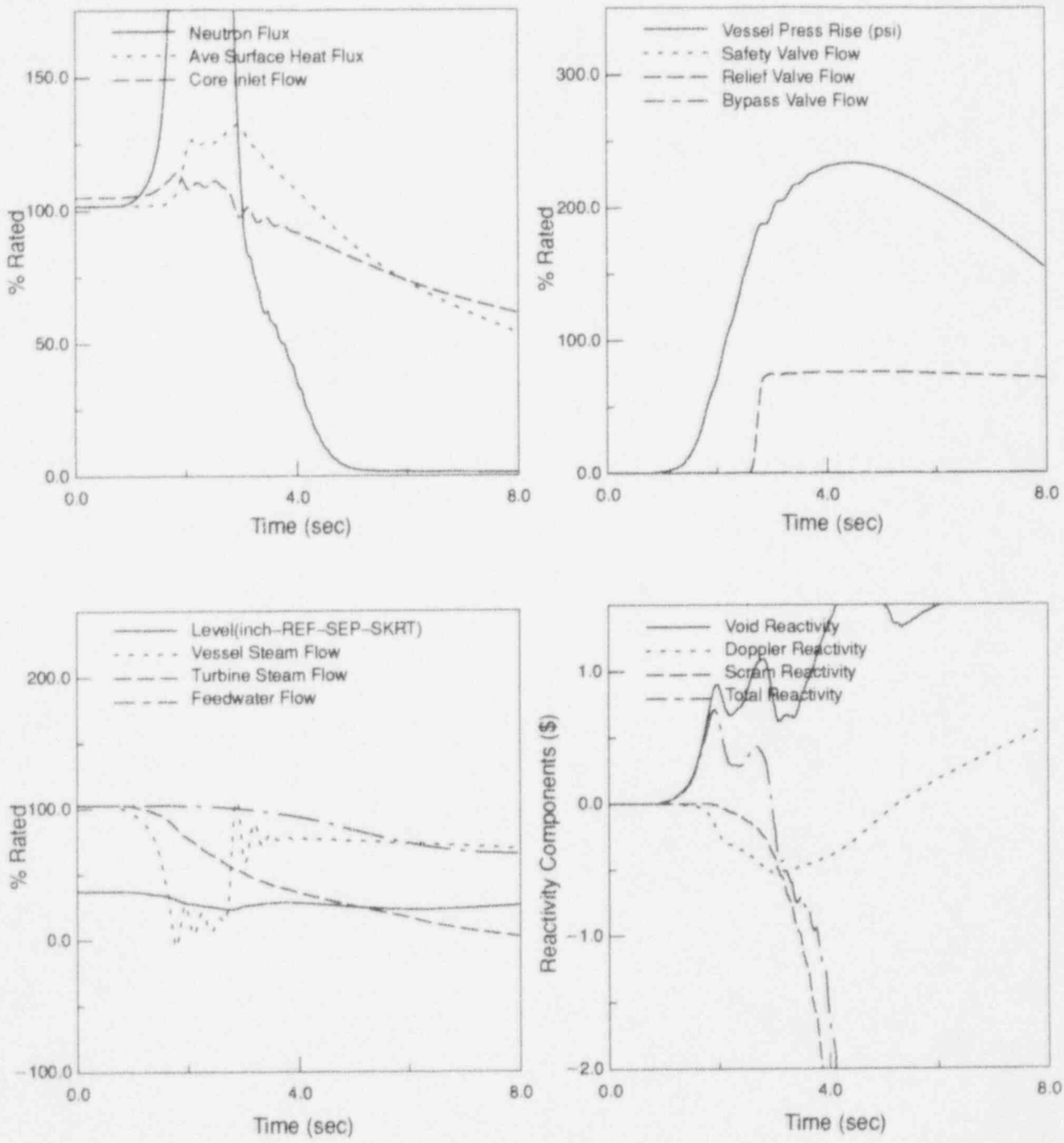


Figure 5 Plant Response to MSIV Closure (Flux Scram) (BOC11 to EOC11 with ICF)

Appendix A
Analysis Conditions

To reflect actual plant parameters accurately, the values shown in Table A–1 were used this cycle.

Table A–1

Parameter	Analysis Value	
	ICF	MSIVOOS
Thermal power, MWt	2436.0	2436.0
Core flow, Mlb/hr	80.8[3]	80.8[3]
Reactor pressure, psia	1036.0	1036.0
Inlet enthalpy, BTU/lb	528.0	528.0
Non–fuel power fraction	0.038	0.038
Steam flow analysis, Mlb/hr	10.48	10.48
Dome pressure, psig	1005.7	1019.8
Turbine pressure, psig	950.0	919.3
No. of Safety/Relief Valves	9	11
Relief mode lowest setpoint, psig	1116.0	1116.0
Recirculation pump power source	On–site[4]	On–site[4]
Turbine control valve mode of operation	Partial arc	Partial arc

3. At increased (105%) core flow.
4. Bounds operation with off–site power source for reload licensing events for Cycle 11.

Appendix B
Main Steamline Isolation Valve Out of Service

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 11, the EOC11–3000 MWd/MT to EOC11 MCPR limits presented in Section 11 of the body of this report are bounding and should be applied when operating in the MSIVOOS mode at any time during the cycle. The peak steam line and peak vessel pressures for the limiting overpressurization event (MSIV closure with flux scram) was not calculated for the MSIVOOS mode of operation because in the MSIVOOS mode it is required that all S/RVs be operational versus the assumed 2 S/RVs OOS for 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 psi, when compared to the same case evaluated with all (four) steamlines operational.

Reference

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

Appendix C
Reload Unique Anticipated Operational Occurence (AOO) Analysis Input

The data previously recorded in Appendix C (input to be used in the analysis of the cold water injection transient) (Inadverent startup of HPCI system), has been eliminated. The basis of this is the information contained in Reference C–1.

Reference

C–1. *Determination of Limiting Cold Water Event*, March 14, 1994 letter from J.F. Klapproth (GE Nuclear Energy) to USNRC.

Appendix D
Feedwater Controller Failure Analysis

The Feedwater Controller Failure (FWCF) (maximum demand) AOO is an increase in coolant inventory event normally checked on a cycle–by–cycle basis to determine if this AOO could potentially alter the cycle MCPR operating limit. The FWCF AOO is basically a two part event. The first portion is an increase in feedwater flow (to maximum capacity) and the second part is a turbine trip (on high water level) with bypass. The severity of the FWCF AOO is highly dependent upon the size of the turbine bypass system.

BSEP Unit 2 has a large turbine bypass capacity (88% of rated steam flow) and the FWCF ΔCPR has always been bounded by the load rejection or turbine trip without bypass. The FWCF analysis for Cycle 8 resulted in an Option B ΔCPR value of less than 0.08. The limiting AOO for Cycles 9, 10 and 11 was the load rejection without bypass with Option B ΔCPRs of 0.21, 0.25 and 0.24, respectively. The cycle–to–cycle variations of the feedwater controller failure event's ΔCPRs and of the load rejection event's ΔCPRs are smaller than the relatively large differences between the FWCF event's and load rejection event's. This trend is not affected by the GE8x8NB–3 fuel design. Therefore, this AOO will not be limiting for Cycle 11 and was not analyzed.

Appendix E
Maximum Extended Operating Domain

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 11 and documented herein is consistent with and provide 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.

Reference E–1
Maximum Extended Operating Domain Analysis for Brunswick Steam Electric Plant, NEDC–31554P, GE Nuclear Energy (Proprietary), February 1989.

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