NEDO-22192
DRF L12-00540
82NED080
CLASS I
JULY 1982

GENERAL ELECTRIC BOILING WATER REACTOR EXTENDED LOAD LINE LIMIT ANALYSIS FOR QUAD CITIES NUCLEAR POWER STATION UNIT 1 CYCLE 7 AND UNIT 2 CYCLE 6

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FOR
QUAD CITIES NUCLEAR POWER STATION
UNIT 1 CYCLE 7 AND UNIT 2 CYCLE 6

NUCLEAR POWER SYSTEMS DIVISION • GENERAL ELECTRIC COMPANY
SAN JOSE, CALIFORNIA 95125

GENERAL ELECTRIC

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TABLES

ILLUSTRATIONS

1. SUMMARY

This report justifies the expansion of the operating region of the power/flow map for Quad Cities Nuclear Power Station Unit 1 Cycle 7 and Unit 2 Cycle 6. The underlying technical analysis is referred to as the Extended Load Line Limit Analysis (ELLLA).

Previous analyses of this type, the Load Line Limit Analysis (LLLA) for BWR/3's did not include analyses for rated power reduced flow operation, and for BWR/4's routinely included analyses at rated power and minimum flows of 91 to 94% of rated. In early 1981, an ELLLA was performed for a typical BWR/3 to support operation at rated power with flow as low as 87%. This work draws on the previous analyses to develop a set of restricted generic conclusions regarding applicability of the license basis safety analyses to operation within this expanded domain (Figure 1-1). It is further shown that the Quad Cities Nuclear Power Stations Unit 1 Cycle 7 and Unit 2 Cycle 6 for the current GE fuel type meets the conditions of validity of the generic conclusions. The consequences of events initiated from within the extended domain are bounded by the consequences of the same events initiated from the license basis condition.

Recent analyses (Reference 1) justify the modification of the operating envelope defined by the power/flow curve while remaining within previously established operating limits and the Preconditioning Interim Operating Management Recommendations (PCIOMRs). The operating envelope is modified to include the extended operating region bounded by the 108% APRM rod block line, the rated power line, and the rated load line.

The discussion and analyses presented show that all safety bases normally applied to Quad Cities Nuclear Power Station Units 1 and 2 are satisfied throughout Unit 1 Cycle 7 and Unit 2 Cycle 6 for operation within this envelope.

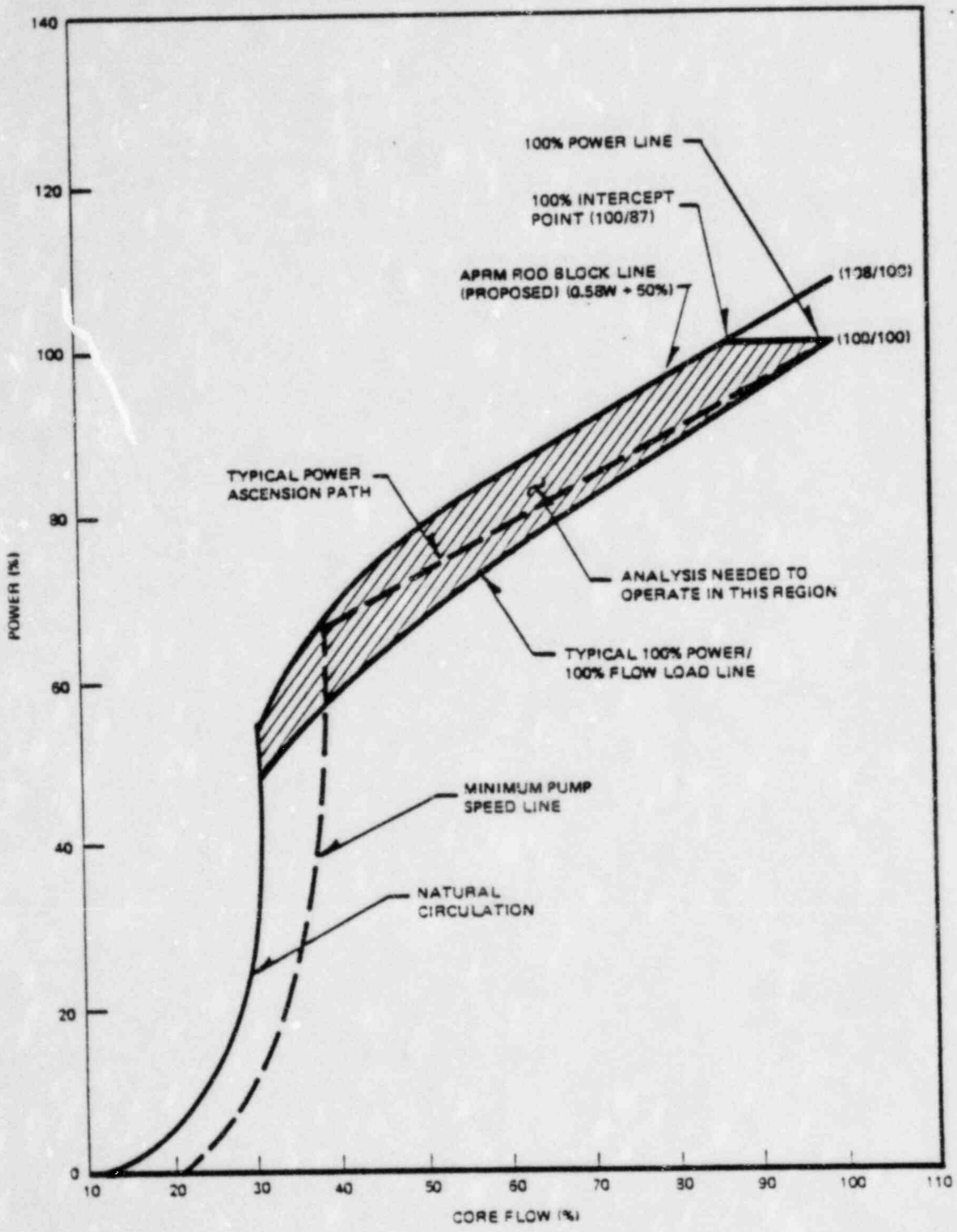

Figure 1-1. Quad Cities Proposed Operating Power/Flow Map

2. INTRODUCTION

Two factors which restrict the flexibility of a BWR during power ascension in proceeding from the low-power/low-core-flow condition to the high-power/high-core-flow condition are: (1) the FSAR power/flow curve, and (2) PCIOMRs.

If the rated load line control rod pattern is maintained as core flow is increased, changing equilibrium xenon concentrations will result in less than rated power at rated core flow. In addition, fuel pellet-cladding interaction considerations inhibit withdrawal of control rods at high power levels. The combination of these two factors can result in the inability to attain rated core power directly.

This report provides the analytical basis for Quad Cities Nuclear Power Station Units 1 and 2 operation during Cycle 7 Unit 1 and Cycle 6 Unit 2 under a modified operating envelope to permit improved power ascension capability to full power within the design bases previously applied.

The operating envelope is modified to include the extended operating region bounded by the 108% APRM rod block line, the rated power line, and the rated load line.

3. DISCUSSION

3.1 BACKGROUND

Operation of the Quad Cities Nuclear Power Station Unit 1 Cycle 7 and Unit 2 Cycle 6 utilizing the power/flow map is described in Chapter 3 of the FSAR (Reference 2). This section of the FSAR describes the basic operating envelope (Figure 3.2.3) within which normal reactor opeations are conducted and provides the basic philosophy behind the power/flow curve. FSAR Figure 3.2.3 is reproduced as Figure 3-1 of this document.

This analysis expands the operating domain along the 108% APRM rod block* line to 100% power at 87% flow. Rated power operation at any flow between 87% and 100% is acceptable within the constraints of the rod block monitor system. Figure 1-1 shows the proposed operating map.

Certain terminology from the previous Load Line Limit Analyses is retained herein:

Rod Block Intercept Point - 85% power/61% flow.

100% Intercept Point - lowest flow point at which rated power operation is acceptable. (87% flow for Quad Cities Nuclear Power Station.)

Rod Intercept Line - a straight line between the Rod Block Intercept Point and the 100% Intercept Point. Because the latter point lies on the APRM Rod Block line, no Rod Intercept Line exists for Quad Cities Nuclear Power Station.

3.2 ANALYTICAL BASIS

To provide relief from the operating restrictions inherently imposed during ascension to power by the existing power/flow curve and PCIOMRs, a modified power/flow curve has been derived. In deriving this operating curve, five design basis objectives were specified:

*RB = 0.58 W+50% where W is recirculation flow in percent of rated.

1. For those transients and accidents that are sensitive to variations in power and flow, the 100% power/100% flow (licensing basis for BWR/2 and 3's) point and the 105% power/100% flow (licensing basis for BWR/4) point must be shown to be a more limiting condition than any condition within the expanded operating region (i.e., the shaded region of Figure 1-1).

2. In no instance shall the ratio of power to flow intentionally exceed the ratio defined by the APRM rod block line.

3. The slope of the APRM rod block line must be such that flow increases are capable of compensating for xenon buildup while increasing reactor power.

4. The consequences of all accidents and transients analyzed in the FSAR and subsequent amendments and the license submittals must remain within the limits normally specified for such events.

5. Reactor power ascension from minimum recirculation pump speed to full power shall be directly attainable through combined control rod movement and recirculation flow increase without violation of either the power/flow line or PCIOMRs.

To meet these objectives, analyses were performed for Quad Cities Nuclear Power Station and other typical BWRs. From these analyses conclusions were drawn concerning the safety consequences of operation in the extended operating region (shaded area of Figure 1-1). It was shown by specific analyses of the current GE fuel type that these conclusions were applicable to Quad Cities Nuclear Power Station, Unit 1 Cycle 7 and Unit 2 Cycle 6 (QCNPS-1C7, 2C6).

3.3 ANALYSIS AND RESULTS

3.3.1 Stability

3.3.1.1 Channel Hydrodynamic Conformance to the Ultimate Performance Criterion

The channel performance calculation for Quad Cities Nuclear Power Station, Unit 1 Cycle 7 and Unit 2 Cycle 6 (QCNPS-1C7, 2C6) is presented in References 3 and 4. The decay ratios are reproduced below:

Channel Hydrodynamic Performance			Extrapolated Rod Block Line* Natural Circulation Line
Unit	Cycle	Channel Type	Decay Ratio x_2/x_o
1	7	P8x8R Channel	0.18
		8x8 Channel	0.28
2	6	P8x8R Channel	0.17
		8x8 Channel	0.27

At this most responsive condition, the most responsive channels are clearly within the bounds of the ultimate performance criteria of $\leq$1.0 decay ratio at all attainable operating conditions.

3.3.1.2 Reactor Conformance to Ultimate Performance Criterion

The decay ratios determined from the limiting reactor core stability conditions are presented in References 3 and 4. The most responsive case fo this analysis is the extrapolated rod block line* - natural circulation conditions.

Unit	Cycle	Extrapolated Rod Block Line* Natural Circulation Power Core Decay Ratio, x_2/x_o
1	7	0.57
2	6	0.53

*RB $\leq$ 0.58 W + 50%, where W is recirculation flow in % of rated.

These calculations show the QCNPS reactors to be in compliance with the ultimate performance criteria, including the most responsive condition.

3.3.2 Loss-of-Coolant Accident

A discussion of low-flow effects on LOCA analyses for all operating plants (Reference 5) has been presented to and was approved by the NRC (Reference 6). The LOCA analysis for QCNPS-1C7, 2C6 (contained in Reference 7) is applicable in the power flow domain discussed in this report.

3.3.3 Pressurization Transients

As shown in Reference 2, the most limiting transient for QCNPS-1C7, 2C6 is the Load Rejection without bypass. The results of numerous transient evaluations (Tables 3-1 through 3-9) at various power/flow conditions demonstrate that transients originated from within the extended operating domain are less severe than the limiting transient at the license basis condition.

This trend was specifically demonstrated for QCNPS-1C7, 2C6 by analyzing the Load Rejection w/o Bypass, Feedwater Controller Failure, and MSIV Closure with Flux Scram events at the limiting point in the extended region (100/87). and comparing the results to those for the licensing basis point (100/100). Those comparisons are shown in Tables 3-4, 3-6, and 3-8, and show that the (100/87) point results are bounded by the licensing basis results.

3.3.3.1 Changes in Nuclear Characteristics

The end-of-cycle (EOC) conditions for the various plants and power/flow conditions were calculated in different ways depending on the plant cycle operating plan. For Plant H (see Tables 3-1 through 3-9), the 100/100 EOC point was determined by assuming rated operation (100/100), and by a Haling power shape throughout the cycle (normal practice). The reduced flow points were determined by using the same exposure point and simply reducing the flow. In this case, the exposures for all three points (100/100, 100/92, and 100/87) were identical, only the power shape changed. For other plants, different combinations of Haling "burns" were assumed resulting in unique exposures for each power/flow combination.

From a transient viewpoint, the important nuclear characteristics which are affected when changing from a high to low flow condition (100/100 to 100/87 or 100/111 to 100/100, etc.) are the scram and void reactivities.

The scram response improves (more negative reactivity) when the flow is reduced. This results because as the flow is reduced, the boiling boundary moves lower in the core, thus causing the axial power shape to peak more toward the bottom (Figure 3-2). This, in turn, results in a stronger scram response because the control rods become "effective" earlier during insertion.

The impact on void reactivity, of changing between high and low flow conditions, is primarily affected by exposure. Since the high and low flow conditions represent only a slight change in exposure, it is expected that the void reactivity characteristics should be very similar. This trend can be observed by comparing the graphs of Figure 3-3.

3.3.3.2 Evaluation of Transient Results

This section provides transient result comparisons between high and low flow initial conditions for various plants, and justification for extending the conclusions reached to QCNPS-1C7, 2C6.

The transient results of primary importance for this study are ΔCPR and peak vessel pressure. Either of these have the potential to impact operation. To ensure that the reduced flow condition (100/87) is bounded by the reference licensing condition (100/100), it is necessary to consider ΔCPR and the peak vessel pressures.

It was established that the reduced flow condition has an improved scram characteristic and similar void reactivity. Therefore transients originated from the reduced flow condition should exhibit a marked improvement. The results for QCNPS-1C7, 2C6 demonstrated this trend as shown in Tables 3-4 through 3-9.

The Plant H results for 100/100, 100/92, and 100/87 also show a clear trend of decreasing ΔCPR with decreasing flow for both LR w/o BP and FWCF. The peak vessel pressure for the MSIV flux scram event was unchanged between 100/100 and 100/92 (the 100/87 condition was not evaluated).

Similar trends exist for other typical BWRs as shown in the above tables.

3.3.4 Rod Withdrawal Error

The effective RBM setpoint is a function of power and flow. Above the rated rod line, the rod block will occur with less rod withdrawal. Thus, the evaluation at rated is conservative for operation above the rated load line.

Table 3-1

PLANT CHARACTERISTICS

	Plant												
	A	B	C	D	E	F	G	H	K	L	M	N	QCNPS-1&2
Number of Fuel Bundles	560	764	560	764	368	240	560	484	548	560	560	764	724
Rated Thermal Power (MWt)	2436	3293	2436	3293	1593	997	2436	1670	2381	2436	2436	3293	2511
Rated Core Flow (Mlb/hr)	77.0	102.5	77.0	102.5	49.0	29.7	77.0	57.6	73.5	78.5	77.0	100.0	98.0
Relief Valve Setpoint (psig)	1090	1105	1105	1105	1090	1065	1090	1108	1080	1080	1090	1110	1130
Relief Valve Capacity (No./%NBR)	11/85.7	11/66.0	11/87.4	11/66.0	6/72.0	4/79.0	11/89.6	7/83.0	7/57.1	11/85.7	11/85.7	16/99.0	4/22.8
Safety Valve Setpoint (psig)	--	1250	--	1230	1240	1210	--	--	1240	--	--	--	1252
Safety Valve Capacity (No./%NBR)	--	2/14.8	--	2/13.6	2/18.9	6/122.4	--	--	3/19.8	--	--	--	8/52.8
Control Rod Drive Specification	67B	67B	67B	67B	67B	67B & MST*	67B	67B	67B	67B	67B	67B	67B

*T (% insertion) = 0.375 (5), 0.776 (20), 1.57 (50), 2.75 (90), + 200 msec interrogation delay.

Table 3-2a

TRANSIENT INPUT DATA AND OPERATING CONDITIONS FOR LICENSE BASIS POINT

	Plant													
	A	B	C	D	E	F	G	H	K	L	M	N	QCNPS-1	QCNPS-2
Thermal Power (MWt/%)	2533/104	3441/104	2533/104	3440/104	1657/104	997/100	2536/104	1670/100	2482/104	2537/104	2535/104	3440/105	2511/100	2511/100
Steam Flow (Mlb/hr/%)	10.96/105	14.10/105	10.99/105	14.0/105	7.18/105	4.07/100	11.0/105	6.78/100	9.56/105	10.5/105	10.96/105	14.15/105	9.8/100	9.8/100
Core Flow (Mlb/hr/%)	77.0/100	102.5/100	77.0/100	102.5/100	49.0/100	29.7/100	77.0/100	57.6/100	73.5/100	78.5/100	77.0/100	100.0/100	98/100	98/100
Dome Pressure (psig)	1019	1020	1020	1019	1020	1005	1020	1025	1020	1020	1019	1020	1005	1005
Turbine Pressure (psig)	958	960	960	959	960	960	960	978	960	960	959	960	950	950
NBP Void Coefficient (¢/%Rg)	-8.76	-6.66	-8.10	-8.32	-9.35	-8.93	-7.68	-6.57			--		-5.41	-5.97
TAF Void Coefficient (¢/%Rg)	-10.93	-8.[illegible]	-10.11	-10.40	-11.69	-11.16	-10.00	-8.22			--		-6.76	-7.47
NBP Doppler Coefficient (¢/°F)	-0.1985	-0.2283	-0.1938	-0.2318	-0.2302	-0.222	-0.225	-0.223			--		-0.226	-0.212
TAF Doppler Coefficient (¢/°F)	-0.1886	-0.2169	-0.1841	-0.2202	-0.2187	-0.211	-0.214	-0.212			--		-0.215	-0.202
Average Fuel Temperature (°F)	1519	1337	1538	1360	1359	1377	1357	1171			--		1168	1196
NBP Scram Worth ($)	-39.09	-39.28	-38.85	-36.75	-39.17	-46.31	-38.36	-37.05			--		-46.31	-46.31
TAF Scram Worth ($)	-31.27	-31.42	-31.08	-29.40	-31.34	-37.05	-30.69	-29.64			--		-37.05	-37.05

Table 3-2b

TRANSIENT INPUT DATA AND OPERATING CONDITIONS FOR 100% INTERCEPT POINT

	Plant											
	A	B	C	D	E	F	G	H*	K	L	M	QCNPS-1	QCNPS-2
Thermal Power (MWt/%)	2436/100	3293/100	2436/100	3293/100	1593/100	N/A	2436/100	1670/100	2381/100	2436/100	3293/100	2511/100	2511/100
Steam Flow (Mlb/hr/%)	10.47/100	13.42/100	10.47/100	13.38/100	6.84/100		10.47/100	6.77/100	9.57/100	10.03/100	13.46/100	9.8/100	9.8/100
Core Flow (Mlb/hr/%)	72.4/94	93.3/94	72.4/94	93.3/94	45.2/92.2		72.3/94	53.0/92	73.5/94	73.8/94	87.0/87	85.3/87	85.3/87
Dome Pressure (psig)	1012	1013	1014	1013	1014		1021	1022	1014	1013	1003	1005	1005
Turbine Pressure (psig)	957	978	959	958	960		967	977	959	958	948	950	950
NDP Void Coefficient (¢/%Rg)	-9.16	-6.95	-8.65	-8.90	-9.98		-7.65		--				
TAP Void Coefficient (¢/%Rg)	-11.45	-8.69	-10.81	-11.12	-12.47		-10.49						
NDP Doppler Coefficient (¢/°F)	-0.2278	-0.2281	-0.2219	-0.2305	-0.2283		-0.225						
TAP Doppler Coefficient (¢/°F)	-0.2164	-0.2167	-0.2108	-0.2190	-0.2169		-0.214						
Average Fuel Temperature (°F)	1472	1295	1490	1317	1321		1357						
NDP Scram Worth ($)	-39.39	-39.41	-38.81	-36.84	-39.29		-38.46						
TAP Scram Worth ($)	-31.51	-31.53	-31.05	-29.47	-31.43		-30.77						

N/A - Not Analyzed
*Plant H analyzed at 92 & 87% flow.

Table 3-3a

GETAB ANALYSIS INITIAL CONDITIONS FOR LICENSE BASIS POINT

	Plant													
	A	B	C	D	E	F	G	H	K	L	M	N	QCNPS-1	QCNPS-2
Core Power (MWt)	2436	3293	2436	3293	1593	947	2436	1670	2381	2436	2436	3293	2511	2511
Core Flow (Mlb/hr)	77.0	102.5	77.0	102.5	49.0	29.7	77.0	57.6	73.5	78.5	77.0	100.0	98	98
Reactor Pressure (psia)	1035	1035	1035	1035	1035	1035	1035	1038	1035	1035	1035	1046	1035	1035
Inlet Enthalpy (Btu/lb)	526.9	521.5	526.9	521.5	526.3	520.7	526.9	524.3	520.4	523.7	526.9	521.7	523.7	523.7
Nonfuel Power Fraction	0.04	0.04	0.04	0.04	0.04	0.035	0.04	0.035	0.04	0.04	0.04	0.04	0.04	0.04
Axial Peaking Factor	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
7x7 Fuel														
Local peaking factor	1.25		1.24	1.24	1.24				1.24	1.24				
Radial peaking factor	1.17		1.23	1.37	1.22				1.21	1.33				
R-factor	1.100		1.100	1.080	1.100				1.100	1.100				
Bundle power (MWt)	5.012		5.267	5.794	5.173				5.489	5.651				
Bundle flow (10^3lb/hr)	127.2		125.8	122.5	126.2				122.6	125.5				
8x8 Fuel														
Local peaking factor	1.22		1.22		1.22			1.22			1.22		1.22	1.22
Radial peaking factor	1.24		1.32		1.29			1.52			1.35		1.58	1.62
R-factor	1.098		1.098		1.098			1.098			1.098		1.098	1.098
Bundle power (MWt)	5.806		5.806		5.466			5.331			5.753		5.372	5.505
Bundle flow (10^3lb/hr)	118.3		116.2		116.0			104.2			115.6		109.3	108.78
8x8R Fuel														
Local peaking factor	1.22	1.26	1.20	1.20			1.20	1.20	1.20	1.20	1.20		1.20	
Radial peaking factor	1.39	1.61	1.46	1.56			1.52	1.67	1.54	1.60	1.50		1.73	
R-factor	1.051	1.051	1.051	1.058			1.051	1.052	1.051	1.052	1.051		1.051	
Bundle power (MWt)	5.966	6.935	6.220	6.529			6.489	5.618	6.553	6.815	6.397		5.849	
Bundle flow (10^3lb/hr)	118.2	109.3	117.0	110.6			112.1	97.2	110.4	112.2	115.2		106.6	
P8x8R Fuel														
Local peaking factor							1.20	1.20		1.20	1.20	1.20	1.20	1.20
Radial peaking factor							1.52	1.63		1.66	1.48	1.54	1.71	1.75
R-factor							1.051	1.052		1.052	1.051	1.050	1.051	1.051
Bundle power (MWt)							6.472	5.496		6.828	6.397	6.496	5.794	5.921
Bundle flow (10^3lb/hr)							112.4	97.9		113.0	115.2	104.2	108.5	106.41

Table 3-3b

GETAB ANALYSIS INITIAL CONDITIONS FOR 100% INTERCEPT POINT

	Plant														
	A	B	C	D	E	F	G	H*	H*	K	L	M	N	QCNPS-1	QCNPS-2
Core Power (MWt)	2436	3293	2436	3293	1593	N/A	2436	1620	1670	2381	2436	2436	3293	2511	2511
Core Flow (Mlb/hr)	72.4	96.4	72.4	93.3	45.2		72.4	53.0	50.4	69.1	73.8	72.4	87.0	85.3	85.3
Reactor Pressure (psia)	1034	1034	1033	1033	1034		1034	1037	1036	1034	1034	1034	1033	1033	1033
Inlet Enthalpy (Btu/lb)	525.5	519.9	525.6	518.8	524.5		525.5	522.1	520.8	518.5	522.2	525.5	517.9	520	520
Nonfuel Power Fraction	0.04	0.04	0.04	0.04	0.04		0.04	0.035	0.035	0.04	0.04	0.04	0.04	0.035	0.035
Axial Peaking Factor	1.40	1.40	1.40	1.40	1.40		1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
7x7 Fuel															
Local peaking factor	1.24		1.24	1.24	1.24					1.24	1.24	1.22			
Radial peaking factor	1.19		1.25	1.36	1.22					1.24	1.36	1.36			
R-factor	1.100		1.100	1.080	1.100					1.100	1.100	1.098			
Bundle power (MWt)	5.058		5.336	5.749	5.179					5.466	5.798	5.784			
Bundle flow (10^3lb/hr)	119.2		117.5	104.0	116.1					115.1	125.5	107.2			
8x8 Fuel															
Local peaking factor	1.22		1.22	1.22	1.22			1.22	1.22	1.22				1.22	1.22
Radial peaking factor	1.27		1.35	1.40	1.30			1.52	1.52	1.52				1.58	1.62
R-factor	1.098		1.098	1.096	1.098			1.098	1.098	1.098				1.098	1.098
Bundle power (MWt)	5.402		5.736	5.912	5.515			5.143	5.100	6.454				5.362	5.500
Bundle flow (10^3lb/hr)	110.1		108.1	93.7	106.1			95.2	90.2	98.8				93.93	93.22
8x8R Fuel															
Local peaking factor	1.20	1.24	1.22	1.20			1.20	1.20	1.20	1.20	1.20	1.20		1.20	
Radial peaking factor	1.40	1.58	1.48	1.53			1.51	1.67	1.67	1.53	1.62	1.50		1.71	
R-factor	1.051	1.051	1.051	1.058			1.051	1.052	1.052	1.051	1.052	1.051		1.051	
Bundle power (MWt)	5.942	6.637	6.310	6.401			6.389	5.612	5.600	6.551	6.879	6.402		5.795	
Bundle flow (10^3lb/hr)	110.1	94.8	108.9	92.4			105.6	88.8	87.8	102.1	112.9	107.7		91.88	
P8x8R Fuel															
Local peaking factor							1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Radial peaking factor							1.49	1.63	1.63	1.52	1.61	1.47	1.49	1.70	1.75
R-factor							1.051	1.052	1.052	1.051	1.052	1.051	1.050	1.051	1.051
Bundle power (MWt)							6.389	5.494	5.500	6.472	6.858	6.780	6.259	5.751	5.915
Bundle flow (10^3lb/hr)							105.6	89.5	87.8	103.3	114.0	108.4	91.3	93.58	91.0

*Plant H analyzed at 92 and 87% flow

N/A - Not Analyzed

Table 3-4

ASME PRESSURE VESSEL CODE COMPLIANCE: MSIV CLOSURE, FLUX SCRAM

Plant	Initial Power/Flow	Peak Neutron Flux Ø (% initial)	Peak Heat Flux Q/A (% initial)	Peak Steamline Pressure P_{sl} (psig)	Peak Vessel Pressure P_v (psig)
	(104P, 100F)*	849	127	1217	1264
A	(100P, 94F)	1005	128	1211	1254
	(85P, 61F)	834	126	1186	1211
	(104P, 100F)	491	122	1242	1277
B	(100P, 94F)	521	122	1226	1260
	(85P, 61F)	504	120	1192	1217
	(104P, 100F)	741	125	1218	1263
C	(100P, 94F)	860	131	1211	1252
	(85P, 61F)	706	131	1189	1214
	(104P, 100F)	783	125	1266	1295
D	(100P, 91F)	797	130	1251	1280
	(85P, 61F)	405	124	1193	1217
	(104P, 100F)	770	126	1245	1287
E	(100P, 92.2F)	939	126	1247	1271
	(85P, 61F)	897	124	1196	1217
F	(100P, 111F)	617	129	1260	1303
	(104P, 100F)	677*	122	1203	1234
	(100P, 94F)	632*	122	1201	1231
G	(91P, 75F)	507*	123	1180	1205
	(85P, 61F)	405*	123	1182	1199
	(104P, 105F)	702*	122	1202	1235

*The 105% steam-flow licensing basis point corresponds to approximately 104% power.

Table 3-4

ASME PRESSURE VESSEL CODE COMPLIANCE: MSIV CLOSURE, FLUX SCRAM
(Continued)

Plant	Initial Power/Flow	Peak Neutron Flux Ø (% initial)	Peak Heat Flux Q/A (% initial)	Peak Steamline Pressure P_{sl} (psig)	Peak Vessel Pressure P_v (psig)
H	(100P, 100F)	658*	128	1222	1244
	(100P, 92F)	662*	127	1223	1243
	(100P, 87F)	635*	127		
	(92P, 75F)	525*	128	1207	1228
	(85P, 61F)	444*	128	1187	1207
K	(104P, 100F)	446*	124	1243	1270
	(100P, 94F)	440*	122	1234	1261
L	(104P, 100F)	568*	120	1199	1232
	(100P, 94F)	538*	122	1192	1224
	(91P, 75F)	421*	120	1169	1195
	(85P, 61F)	348*	120	1164	1183
	(104P, 105F)	576*	120	1199	1233
M	(104P, 100F)	693*	124	1236	1275
	(100P, 94F)	616*	124	1229	1266
N	(105P, 100F)	602	124	1246	1276
	(100P, 87F)	523	123	1239	1266
QCNPS-1C7	(100P, 100F)	442	126	1303	1321
	(100P, 87F)	425	123	1301	1319
QCNPS-2C6	(100P, 100F)	436	125	1326	1343
	(100P, 87F)	422	122	1322	1338

*% Nominal Rated

Table 3-5

TRANSIENT SUMMARY--TURBINE TRIP WITHOUT BYPASS

Plant	Analysis	Initial Power (% NBR)	Initial Flow (% NBR)	$\dot{\phi}$ (% initial)	$\dot{Q}/A$ (% initial)	$\dot{P}_{sl}$ (psig)	$\dot{P}_v$ (psig)	ΔCPR 7x7	ΔCPR 8x8	ΔCPR 8x8R	ΔCPR P8x8R
A	R	104	100	353	114	1177	1220	0.22	0.30	0.29	--
A	R	100	94	354	114	1172	1215	0.22	0.29	0.29	--
A	R	85	61	247	106	1158	1182	0.09	0.13	0.13	--
B	R	104	100	183	102	1198	1225	--	0.12	0.12	--
B	R	100	94	173	102	1185	1211	--	0.12	0.12	--
B	R	85	61	15C	100	1160	1180	--	0.06	0.06	--
C	R	104	100	260	110	1171	1217	0.16	0.23	0.22	--
C	R	100	94	254	113	1167	1209	0.15	0.21	0.21	--
C	R	85	61	169	105	1155	[illegible]78	0.04	0.07	0.07	--
D	R	104	100	249	109	1186	1228	0.13	0.18	0.18	--
D	R	100	91	249	108	1176	1214	0.12	0.17	0.17	--
D	R	85	61	162	105	1152	1175	0.01	0.02	0.03	--
E	R	104	100	333	115	1207	--	0.20	0.28	--	--
E	R	100	92	325	113	1187	--	0.18	0.26	--	--
E	R	85	61	181	101	1149	--	0.04	0.06	--	--
F[b,c]	O	100	100	889	121	1110	1139	--	--	0.25	0.29
F[b,c]	O	100	111	924	121	1109	1143	--	--	0.28	0.32
F[a,b,c]	O	100	111	849	120	1109	1143	--	--	0.26	0.30
F[b,c,d]	O	100	111	924	121	1108	1141	--	--	0.28	0.32
F[b,d,e]	O	100	100	628	116	1103	1129	--	--		
F[b,d,e]	O	100	111	723	118	1103	1134	--	--	0.22	0.26
QCNPS-1C7	O	100	100	509	119	1290	1301	--	0.27	--	0.29
QCNPS-1C7	O	100	87	443	117	1273	1287	--	0.24	--	0.26
QCNPS-1C7	O	91	75	314	115	1226	1245	--	0.20	--	0.22
QCNPS-2C6	O	100	100	--	--	--	--	--	--	--	--
QCNPS-2C6	O	100	87	358	116	1281	1304	--	--	--	--
QCNPS-2C6	O	91	75	258	114	1244	1262	--	--	--	--
QCNPS-2C6	O	85	61	196	113	1227	1241	--	--	--	--

[a] Feedwater temperature reduction
[b] 1/2 bypass failure
[c] No position scram
[d] Measured scram time
[e] Position scram with 200 msec delay
R-REDY, O-ODYN

Table 3-6

TRANSIENT SUMMARY--LOAD REJECTION WITHOUT BYPASS

Plant	Analysis	Initial Power (% NBR)	Initial Flow (% NBR)	$\dot{\phi}$ (% initial)	$\dot{Q}/A$ (% initial)	$\dot{P}_{sl}$ (psig)	$\dot{P}_v$ (psig)	ΔCPR			
								7x7	8x8	8x8R	P8x8R
A	R	104	100	376	115	1178	1225	0.23	0.31	0.30	--
A	R	100	94	360	115	1173	1216	0.22	0.29	0.29	--
A	R	85	61	251	107	1157	1182	0.09	0.13	0.13	--
B	R	104	100	201	104	1203	1229	--	0.14	0.14	--
B	R	100	94	191	103	1189	1215	--	0.14	0.14	--
B	R	85	61	167	102	1162	1183	--	0.09	0.09	--
C	R	104	100	302	111	1172	1219	0.18	0.25	0.25	--
C	R	100	94	284	114	1168	1210	0.16	0.22	0.22	--
C	R	85	61	168	106	1154	1177	0.04	0.07	0.07	--
D	R	104	100	277	111	1189	1233	0.15	0.21	0.21	--
D	R	100	91	267	115	1180	1219	0.14	0.19	0.19	--
D	R	85	61	176	107	1153	1177	0.03	0.05	0.06	--
E	R	104	100	367	116	1209	--	0.22	0.30	--	--
E	R	100	92	348	114	1188	--	0.19	0.27	--	--
E	R	85	61	179	101	1149	--	0.04	0.07	--	--
F	NOT ANALYZED										
G	ø	104	100	507[b]	114	1186	1208	--	--	0.17	0.17
G	ø	100	94	489[b]	114	1180	1202	--	--	--	--
G	ø	91	75	424[b]	113	1175	1194	--	--	--	--
G	ø	85	61	332[b]	111	1165	1183	--	--	--	--
G	C	104	105	501[b]	113	1184	1207	--	--	0.17	0.18
G[a]	ø	105	100	503[b]	115	1178	1200	--	--	0.18	0.18
G[a]	ø	105	105	481[b]	114	1184	1206	--	--	0.18	0.18
H	ø	100	100	679[b]	124	1206	1230	--	0.35	0.35	0.39
H	ø	100	92	631[b]	122	1206	1228	--	0.31	0.31	0.34
H	ø	92	75	396[b]	120	1183	1202	--	0.25	0.25	0.28
H	ø	85	61	329[b]	122	1195	1208	--	0.23	0.24	0.26
H	ø	100	87	576[b]	121	1205	1227	--	0.30	0.30	0.33
K	ø	104	100	502[b]	117	1179	1213	0.14	0.19	0.19	0.19
K	ø	100	94	469[b]	117	1174	1206	0.13	0.17	0.17	0.19
L	ø	104	100	338[b]	108	1166	1189	--	--	--	--
L	ø	100	94	320[b]	108	1160	1182	--	--	--	--
L	ø	91	75	267[b]	108	1145	1168	--	--	--	--
L	ø	85	61	216[b]	106	1145	1160	--	--	--	--
L	ø	104	105	333[b]	108	1167	1191	0.07	--	0.11	0.11
L[a]	ø	105	105	336[b]	108	1165	1188	0.08	--	0.11	0.11
L[a]	ø	105	100	346[b]	109	1166	11[illegible]	[illegible].08	--	0.11	0.11
M	ø	104	100	653	120	1208	12[illegible]	[illegible]	0.22	0.22	0.24
M	ø	100	94	596	120	1197	123[illegible]	[illegible]	0.20	0.20	0.23
N	ø	105	100	447	118	1189	1218	--	--	--	0.19
N	ø	100	87	453	117	1183	1204	--	--	--	0.18
QCNPS-1C7	ø	100	100	558	121	1303	1315	--	0.29	--	0.31
QCNPS-1C7	ø	100	87	486	118	1279	1293	--	0.25	--	0.27
QCNPS-1C7	ø	91	75	360	116	1231	1250	--	0.22	--	0.24
QCNPS-2C6	ø	100	100	497	119	1307	1322	--	0.27	--	0.29
QCNPS-2C6	ø	100	87	400	117	1307	1322	--	0.22	--	0.25
QCNPS-2C6	ø	91	75	294	116	1247	1267	--	0.19	--	0.21
QCNPS-2C6	ø	85	61	216	114	1231	1246	--	0.15	--	0.18

[a]Feedwater temperature reduction
[b]% nominal rated

Table 3-7

TRANSIENT SUMMARY--LOSS OF FEEDWATER HEATING

Plant	Analysis	Initial Power (% NBR)	Initial Flow (% NBR)	$\dot{\phi}$ (% initial)	$\dot{Q}/A$ (% initial)	$\dot{P}_{sl}$ (psig)	$\dot{P}_v$ (psig)	ΔCPR 7x7	ΔCPR 8x8	ΔCPR 8x8R	ΔCPR P8x8R
A	R	104	100	116	114	1018	1068	0.11	0.13	0.13	—
A	R	100	94	116	114	1012	1057	0.11	0.13	0.13	—
A	R	85	61	117	117	994	1020	0.13	0.15	0.15	—
B	R	104	100	116	115	1008	1064	—	0.13	0.13	—
B	R	100	94	116	116	1002	1053	—	0.13	0.13	—
B	R	85	61	121	121	988	1019	—	0.19	0.19	—
C	R	104	100	118	116	1019	1068	0.11	0.13	0.13	—
C	R	100	94	116	114	1013	1057	0.12	0.14	0.14	—
C	R	85	61	111	111	992	1017	0.13	0.15	0.15	—
D	R	104	100	117	117	1012	1068	0.15	0.16	0.16	—
D	R	100	91	118	117	1004	1053	0.13	0.14	0.14	—
D	R	85	61	123	128	990	1022	0.18	0.19	0.20	—
E	R	104	100	121	119	1023	—	0.14	0.16	—	—
E	R	100	92	121	120	1016	—	0.14	0.17	—	—
E	R	85	61	125	124	999	—	0.19	0.21	—	—
F	R	100	100	112	111	1002	1043	—	—	0.14	0.14
F	R	100	111	116	113	1041	1083	—	—	0.14	0.14
F[a]	R	100	111	110	110	1023	1073	—	—	0.14	0.14

[a]MST

Table 3-8

TRANSIENT SUMMARY--FEEDWATER CONTROLLER FAILURE

Plant	Analysis	Initial Power (% NBR)	Initial Flow (% NBR)	$\dot{\phi}$ (% initial)	Q/A (% initial)	P_{sl} (psig)	P_v (psig)	ΔCPR 7x7	ΔCPR 8x8	ΔCPR 8x8R	ΔCPR P8x8R
A	R	104	100	243	114	1152	1200	0.18	0.25	0.25	--
A	R	100	94	241	115	1150	1193	0.19	0.26	0.26	--
A	R	85	61	184	111	1138	1160	0.13	0.17	0.17	--
B	R	104	100	144	106	1153	1187	--	0.09	0.09	--
B	R	100	94	134	107	1148	1179	--	0.09	0.10	--
B	R	85	61	136	109	1137	1156	--	0.13	0.13	--
C	R	104	100	109	105	1028	1076	0.05	0.06	0.06	--
C	R	100	94	112	110	1022	1067	0.06	0.07	0.08	--
C	R	85	61	117	111	996	1021	0.09	0.10	0.11	--
D	R	104	100	185	111	1147	1193	0.11	0.16	0.16	--
D	R	100	91	174	115	1142	1181	0.09	0.13	0.13	--
D	R	85	61	176	116	1127	1149	0.10	0.12	0.12	--
E	R	104	100	211	111	1146	--	0.14	0.21	--	--
E	R	100	92	188	106	1142	--	0.11	0.17	--	--
E	R	85	61	133	109	1127	--	0.09	0.11	--	--
F	Ø	100	100	214	105	1031	1062	--	--	--	--
F	Ø	100	111	181	104	1021	1062	--	--	--	--
F[a]	Ø	100	111	180	105	1021	1063	--	--	--	--
G	Ø	104	100	293[b]	114	1151	1182	--	--	0.15	0.16
G	Ø	100	94	274[b]	114	1139	1172	--	--	0.15	0.17
G	Ø	91	75	256[b]	114	1133	1160	--	--	0.15	0.16
G	Ø	85	61	207[b]	113	1128	1145	--	--	0.13	0.14
G	Ø	104	105	286[b]	114	1143	1177	--	--	0.16	0.17
G[a]	Ø	105	100	317[b]	119	1148	1177	--	--	0.17	0.18
G[a]	Ø	105	105	125[b]	112	1111	1134	--	--	0.08	0.08
G[a]	Ø	95	105	311[b]	121	1129	1158	--	--	0.21	0.23
H	Ø	100	100	518[b]	124	1169	120[illegible]	--	0.33	0.34	0.37
H	Ø	100	92	488[b]	123	1169	1197	--	0.30	0.30	0.33
H	Ø	100	87	465[b]	122	1170	1194	--	0.29	0.30	0.32
H	Ø	92	75	345[b]	118	1166	1184	--	0.23	0.24	0.26
H	Ø	85	61	230[b]	116	1147	1170	--	0.17	0.19	0.21
K	Ø	104	100	314[b]	114	1135	1172	0.09	0.13	0.14	0.16
K	Ø	100	94	282[b]	116	1131	1165	0.13	0.17	0.17	0.19
L	Ø	104	100	147[b]	108	1137	1161	0.08	--	0.11	0.11
L	Ø	100	94	191[b]	110	1128	1158	0.07	--	0.11	0.12
L	Ø	91	75	188[b]	110	1124	1144	0.07	--	0.11	0.12
L	Ø	85	61	146[b]	109	1119	1138	0.06	--	--	--
L	Ø	104	105	198[b]	110	1136	1166	0.07	--	0.11	0.12
L[a]	Ø	105	105	234[b]	115	1131	1163	0.11	--	0.15	0.16
L[a]	Ø	105	100	126[b]	111	1107	1128	0.06	--	0.08	0.08
M	Ø	104	100	362*	118	1173	1216	--	0.17	0.17	0.19
M	Ø	100	94	332*	118	1170	1210	--	0.16	0.17	0.18
N	Ø	105	100	264	115	1159	1188	--	--	--	0.16
N	Ø	100	87	266	115	1152	1172	--	--	--	0.16
QCNPS-1C7	Ø	100	100	267	115	1136	1172	--	0.15	--	0.16
QCNPS-1C7	Ø	100	87	260	115	1140	1171	--	0.13	--	0.14
QCNPS-1C7	Ø	91	75	202	115	1112	1138	--	0.12	--	0.13
QCNPS-2C6	Ø	100	100	192	115	1150	1189	--	0.14	--	0.23
QCNPS-2C6	Ø	100	87	253	114	1152	1185	--	0.14	--	0.13
QCNPS-2C6	Ø	91	75	193	114	1126	1151	--	0.13	--	0.14
QCNPS-2C6	Ø	85	61	166	115	1107	1127	--	--	--	--

[a]Feedwater temperature reduction
[b]% nominal rated

Table 3-9

TRANSIENT SUMMARY--HIGH PRESSURE COOLANT INJECTION

Plant	Analysis	Initial Power (% NBR)	Initial Flow (% NBR)	$\hat{\phi}$ (% initial)	$\hat{Q/A}$ (% initial)	$\hat{P}_{sl}$ (psig)	$\hat{P}_v$ (psig)	ΔCPR 7x7	ΔCPR 8x8	ΔCPR 8x8R	ΔCPR P8x8R
A	R	104	100	120	113	1017	1068	0.10	0.12	0.12	--
A	R	100	94	123	114	1012	1058	0.11	0.14	0.14	--
A	R	85	61	119	118	995	1021	0.10	0.12	0.12	--
B	R	104	100	113	109	1007	1063	--	0.10	0.10	--
B	R	100	94	115	111	1002	1053	--	0.09	0.09	--
B	R	85	61	117	115	987	1018	--	0.13	0.13	--
C	R	104	100	122	113	1018	1068	0.11	0.14	0.14	--
C	R	100	94	123	117	1012	1057	0.12	0.15	0.15	--
C	R	85	61	120	111	993	1018	0.14	0.16	0.16	--
D	R	104	100	115	111	1010	1065	0.10	0.12	0.12	--
D	R	100	91	115	111	1003	1052	0.09	0.09	0.10	--
D	R	85	61	117	120	987	1019	0.12	0.13	0.13	--
E	R	104	100	--	--	--	--	0.12	0.14	--	--
E	R	100	92	--	--	--	--	0.12	0.14	--	--
E	R	85	61	--	--	--	--	0.16	0.18	--	--

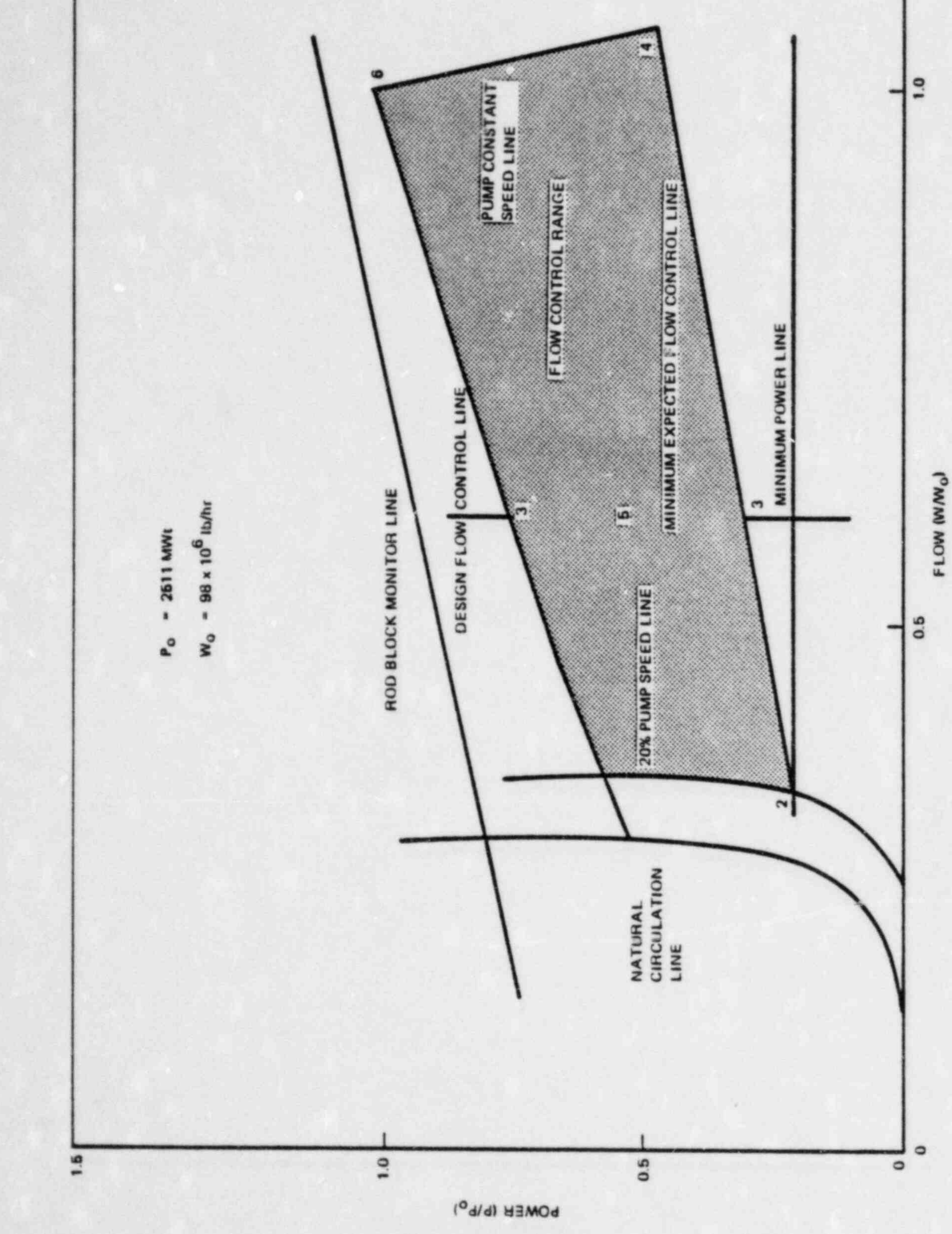

Figure 3-1. Quad Cities Operating Power Flow Map as Shown in FSAR

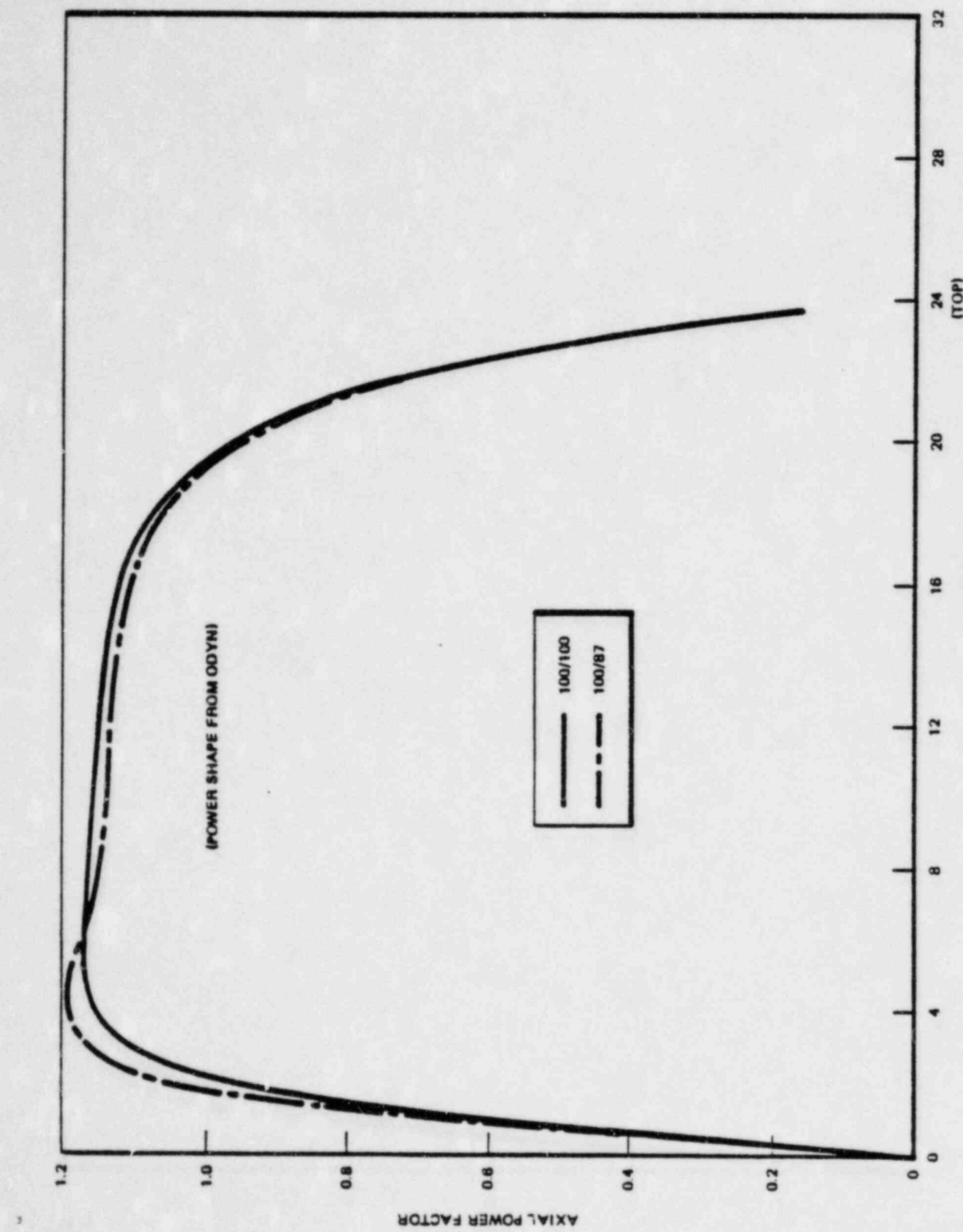

Figure 3-2. Axial Power Shape for 100% and 87% Core Flow, Plant H

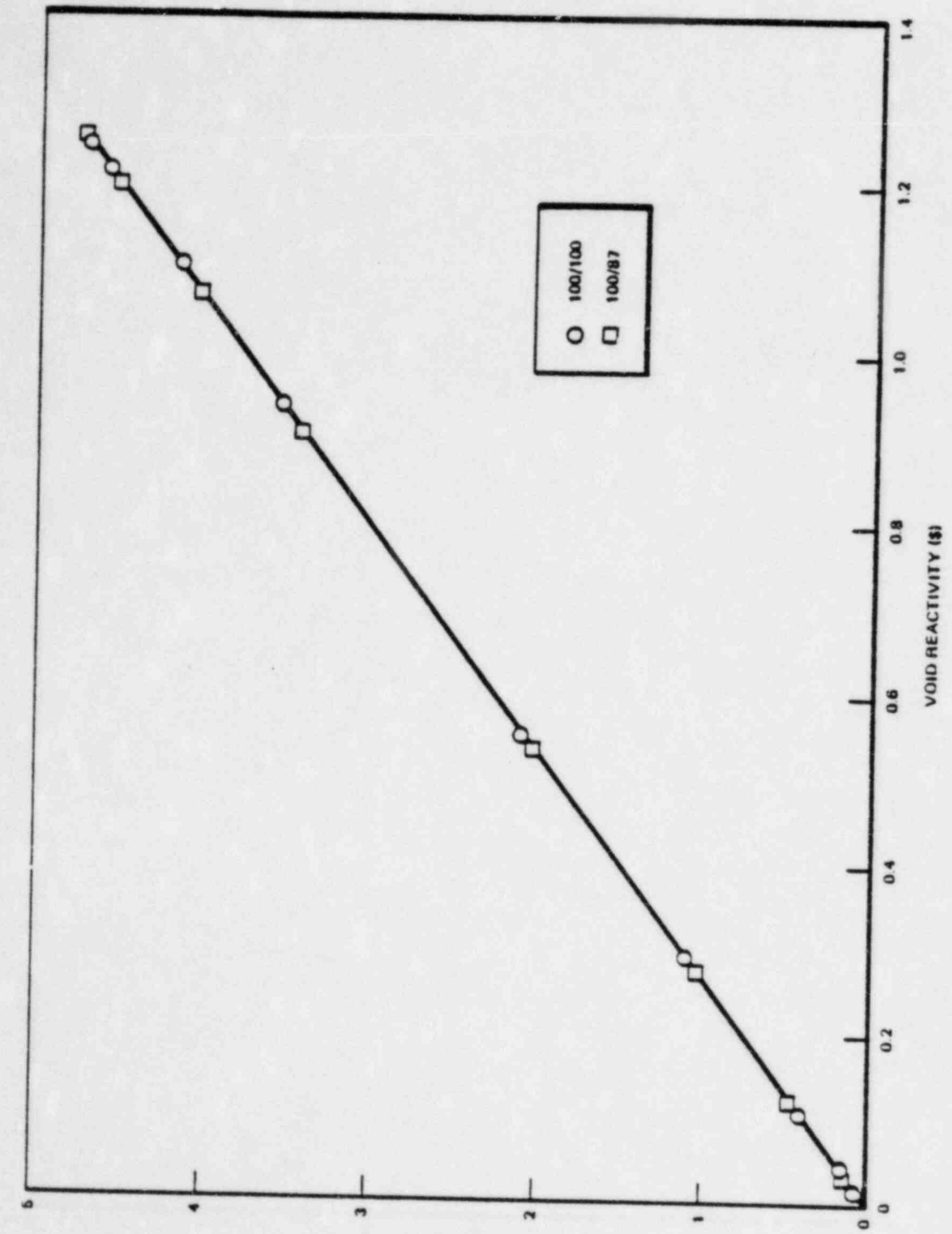

Figure 3-3. Void Reactivity versus Delta Void for LR w/o BP at 100/100 and 100/87, Plant II

4. REFERENCES

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4. "Supplemental Reload Licensing Submittal for Quad Cities Nuclear Power Station Unit 2 Reload 5 (Cycle 6)," General Electric Company, June 1981 (Y1003J01A43).

5. R. L. Gridley (GE), letter to D. G. Eisenhut (NRC), "Review of Low-Core Flow Effects on LOCA Analysis for Operating BWRs," May 8, 1978.

6. D. G. Eisenhut (NRC), letter to R. L. Gridley, enclosing "Safety Evaluation Report Revision of Previously Imposed MAPLHGR (ECCS-LOCA) Restrictions for BWRs at Less Than Rated Flow," May 19, 1978.

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