Exelon Nuclear

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November 6, 2002

United States Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

LaSalle County Station, Unit 2
Facility Operating License No. NPF-18
NRC Docket No. 50-374

Subject: Unit 2 Cycle 9 Core Operating Limits Report (COLR)

Exelon Generation Company (EGC), LLC, in accordance with LaSalle County Station Technical Specifications (TS) Section 5.6.5, "Core Operating Limits Report," is submitting a revision to the Core Operating Limits Report (COLR). The revision incorporates relaxed thermal limits which may be applied when the core average scram time meets the more stringent criteria presented in the COLR. In addition, explicit thermal limits have been established for the equipment out of service (OOS) options of Main Turbine Bypass Valves OOS and Feedwater Heaters OOS.

Should you have any questions concerning this submittal, please contact Mr. Glen Kaegi, Regulatory Assurance Manager, at (815) 415-2800.

Respectfully,

George P. Barnes

George P. Barnes
Site Vice President
LaSalle County Station

Attachment

cc: Regional Administrator - NRC Region III
NRC Senior Resident Inspector - LaSalle County Station

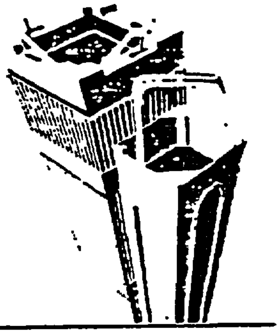
A001

SIEMENS

EMF-2440
Revision 0

LaSalle Unit 2 Cycle 9
Plant Transient Analysis

October 2000



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EMF-2440
Revision 0

LaSalle Unit 2 Cycle 9
Plant Transient Analysis

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Nature of Changes

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1.	All	This is a new document.

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Nomenclature

AOO	anticipated operational occurrence
ComEd	Commonwealth Edison Company
CPR	critical power ratio
EFPH	effective full power hours
EOC	end of cycle
EOD	extended operating domain
EOFP	end of full power
EOOS	equipment out-of-service
FFTR	final feedwater temperature reduction
FHOOS	feedwater heater out-of-service
FWCF	feedwater controller failure
HFR	heat flux ratio
ICF	increased core flow
L2C9	LaSalle Unit 2 Cycle 9
LFWH	loss-of-feedwater heating
LHGR	linear heat generation rate
$LHGRFAC_f$	flow-dependent linear heat generation rate factors
$LHGRFAC_p$	power-dependent linear heat generation rate factors
LHGROL	linear heat generation rate operating limit
LPRM	local power range monitor
LRNB	generator load rejection with no bypass
MCPR	minimum critical power ratio
$MCPR_f$	flow-dependent minimum critical power ratio
$MCPR_p$	power-dependent minimum critical power ratio
MELLLA	maximum extended load line limit analysis
MFC	manual flow control
MSIV	main steam isolation valve
NSS	nominal scram speed
PAPT	protection against power transient
RPT	recirculation pump trip
SLMCPR	safety limit MCPR
SLO	single-loop operation
SPC	Siemens Power Corporation
SRV	safety/relief valve
SRVOOS	safety/relief valve out-of-service
SSLHGR	steady-state LHGR

Nomenclature *(Continued)*

TBVOOS	turbine bypass valve out-of-service
TCV	turbine control valve
TIP	traversing incore probe
TIPOOS	tip machine(s) out-of-service
TSSS	technical specification scram speed
TSV	turbine stop valve
TTNB	turbine trip with no bypass
ΔCPR	change in critical power ratio

1.0 Introduction

This report presents results of the plant transient analyses performed by Siemens Power Corporation (SPC) as part of the reload safety analyses to support LaSalle Unit 2 Cycle 9 (L2C9) operation. The Cycle 9 core contains 348 fresh ATRIUM™-9B* assemblies, 256 previously loaded ATRIUM-9B assemblies and 160 previously loaded GE9 assemblies. Those portions of the reload safety analysis for which Commonwealth Edison Company (ComEd) has responsibility are presented elsewhere. The appropriate operating limits for Cycle 9 operation must be determined in conjunction with results from ComEd analyses. The scope of the transient analyses performed by SPC is presented in Reference 1.

The analyses reported in this document were performed using the plant transient analysis methodology approved by the Nuclear Regulatory Commission (NRC) for generic application to boiling water reactors (Reference 2). The transient analyses were performed in accordance with the NRC technical limitations as stated in the methodology (References 3–7). Parameters for the transient analyses are documented in Reference 8.

The Cycle 9 transient analysis consists of the calculation of the limiting transients identified in Reference 9 to support base case operation† for the power/flow map presented in Figure 1.1. Results are also presented to support operation in the extended operating domain (EOD) and equipment out-of-service (EOOS) scenarios identified in Table 1.1. The analysis results are used to establish operating limits to protect against fuel failures. Minimum critical power ratio (MCPR) limits are established to protect the fuel from overheating during normal operation and anticipated operational occurrences (AOOs). Power-dependent MCPR ($MCPR_p$) limits are required in order to provide the necessary protection during operation at reduced power. Flow-dependent MCPR ($MCPR_f$) limits provide protection against fuel failures during flow excursions initiated at reduced flow. Cycle 9 power- and flow-dependent MCPR limits are presented to protect both ATRIUM-9B and GE9 fuel.

Protection against violating the linear heat generation rate (LHGR) limits at rated and off-rated conditions is provided through the application of power- and flow-dependent LHGR factors

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* ATRIUM is a trademark of Siemens.

† Base case operation is defined as two-loop operation within the standard operating domain, including the ICF and MELLLA regions, with all equipment in-service.

($LHGRFAC_p$ and $LHGRFAC_f$, respectively). These factors or multipliers are applied directly to the steady-state LHGR limit to ensure that the LHGR does not exceed the protection against power transient (PAPT) limit during postulated AOOs. Cycle 9 power- and flow-dependent LHGR multipliers are presented for ATRIUM-9B fuel.

Results of analyses that demonstrate compliance with the ASME Boiler and Pressure Vessel Code overpressurization limit are presented.

The results of the plant transient analyses are used in a subsequent reload analysis report (Reference 15) along with core and accident analysis results to justify plant operating limits and set points.

Table 1.1 EOD and EOOS Operating Conditions

Extended Operating Domain (EOD) Conditions
Increased core flow
Maximum extended load line limit analysis (MELLLA)
Coastdown
Final feedwater temperature reduction (FFTR)
Combined FFTR/coastdown
Equipment Out-of-Service (EOOS) Conditions*
Feedwater heaters out-of-service (FHOOS)
Single-loop operation (SLO) - recirculation loop out-of-service
Turbine bypass valves out-of-service (TBVOOS)
Recirculation pump trip out-of-service (no RPT)
Turbine control valve (TCV) slow closure and/or no RPT
Safety relief valve out-of-service (SRVOOS)
Up to 2 tip machines out-of-service or the equivalent number of TIP channels (100% available at startup)
Up to 50% of the LPRMs out-of-service
TCV slow closure, FHOOS, and/or no RPT

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* EOOS conditions are supported for EOD conditions as well as the standard operating domain. Each EOOS condition combined with 1 SRVOOS, up to 2 TIPOOS (or the equivalent number of channels) and/or up to 50% of the LPRMs out-of-service is supported.

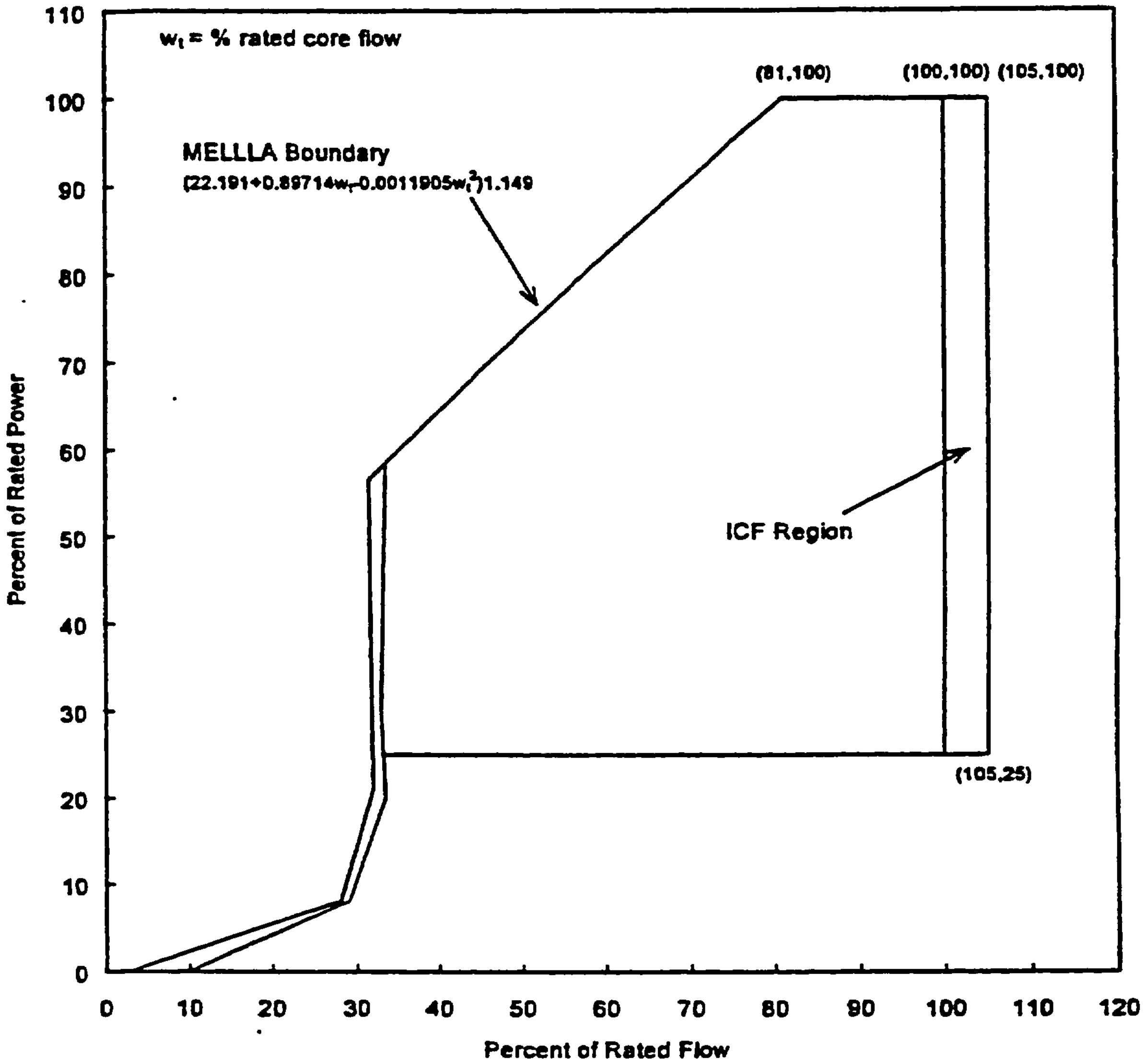

**Figure 1.1 LaSalle County Nuclear Station
Power / Flow Map**

2.0 Summary

The determination of the thermal limits (MCPR limits and LHGRFAC multipliers) for LaSalle Unit 2 Cycle 9 is based on analyses of the limiting operational transients identified in Reference 9. Although the Reference 9 conclusions are based on 18-month cycles, the limiting operational transients identified remain valid for 24-month cycles. The transients evaluated are the generator load rejection with no bypass (LRNB), feedwater controller failure to maximum demand (FWCF) and loss-of-feedwater heating (LFWH). Thermal limits identified for Cycle 9 operation include both MCPR limits and LHGRFAC multipliers. The MCPR operating limits are established so that less than 0.1% of the fuel rods in the core are expected to experience boiling transition during an AOO initiated from rated or off-rated conditions and are based on a two-loop operation MCPR safety limit of 1.11. LHGRFAC multipliers are applied directly to the LHGR limits at reduced power and/or flow conditions to protect against fuel melting and overstraining of the cladding during an AOO. Operating limits are established to support both base case operation and the EOOS scenarios presented in Table 1.1. Operating limits are also established for the EOD and combined EOD/EOOS conditions presented in Table 1.1.

Base case MCPR$_p$ limits and LHGRFAC$_p$ multipliers are based on results presented in Section 3.0. Results presented in Sections 4.0–6.0 are used to establish the operating limits for operation in the EOD, EOOS, and combined EOD/EOOS scenarios.

Cycle 9 MCPR$_p$ limits and LHGRFAC$_p$ multipliers for ATRIUM-9B fuel and MCPR$_p$ limits for GE9 fuel that support base case operation and operation in the EOD, EOOS and combined EOD/EOOS scenarios are presented in Tables 2.1–2.4. Tables 2.1 and 2.2 present base case limits and multipliers for Technical Specifications scram speed (TSSS) insertion times and nominal scram speed (NSS) insertion times, respectively. Table 2.3 presents the limits and multipliers for coastdown operation. The combined FFTR/coastdown limits and multipliers are identified in Table 2.4.

MCPR$_f$ limits for both ATRIUM-9B and GE9 that protect against fuel failures during a slow flow excursion event in manual flow control are presented in Figure 2.1. Automatic flow control is not supported for L2C9. The GE9 MCPR$_f$ limits include the effect of applying the MCPR penalty described in Reference 10. The MCPR$_f$ limits presented are applicable for all EOD and EOOS conditions presented in Table 1.1.

The Cycle 9 $LHGRFAC_f$ multipliers for the ATRIUM-9B fuel are presented in Figure 2.2 and are applicable in all the EOD and EOOS scenarios presented in Table 1.1. Comparison of the Cycle 9 nodal power histories for the rated power pressurization transients with the approved bounding curves to show compliance with the 1% clad strain and centerline melt criteria for GE9 fuel is discussed in Reference 19.

The results of the maximum overpressurization analyses show that the requirements of the ASME code regarding overpressure protection are met for Cycle 9. The analysis shows that the dome pressure limit of 1325 psig is not exceeded and the vessel pressure does not exceed the limit of 1375 psig.

Table 2.1 EOC Base Case and EOOS $MCPR_p$ Limits and $LHGRFAC_p$ Multipliers for TSSS Insertion Times*

EOOS / EOD Condition	Power (% rated)	ATRIUM-9B Fuel		GE9 Fuel
		$MCPR_p$	$LHGRFAC_p$	$MCPR_p$
Base case operation	0	2.70	0.78	2.70
	25	2.20	0.78	2.20
	25	1.91	0.78	1.99
	60	1.46	1.00	1.52
	100	1.41	1.00	1.51
Feedwater heaters out-of-service (FHOOS)	0	2.85	0.69	2.85
	25	2.35	0.69	2.35
	25	2.14	0.69	2.22
	60	1.51	0.97	1.57
	100	1.41	1.00	1.51
Single-loop operation (SLO)	0	2.71	0.78	2.71
	25	2.21	0.78	2.21
	25	1.92	0.78	2.00
	60	1.47	1.00	1.53
	100	1.42	1.00	1.52
Turbine bypass valves out-of-service (TBVOOS)	0	2.70	0.76	2.70
	25	2.20	0.76	2.20
	25	1.98	0.76	2.08
	60	1.52	0.97	1.62
	100	1.43	0.99	1.52

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* Limits support operation with any combination of 1 SRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), up to a 20°F reduction in feedwater temperature (except for conditions with FHOOS), and up to 50% of the LPRMs out of service in the standard, ICF, and MELLLA regions of the power/flow map.

Table 2.1 EOC Base Case and EOOS MCPR$_p$ Limits and LHGRFAC$_p$ Multipliers for TSSS Insertion Times[*]
(Continued)

EOOS / EOD Condition	Power (% rated)	ATRIUM-9B Fuel		GE9 Fuel
		MCPR$_p$	LHGRFAC$_p$	MCPR$_p$
Recirculation pump trip out-of-service (no RPT)	0	2.70	0.78	2.70
	25	2.20	0.78	2.20
	25	1.91	0.78	1.99
	60	1.51	0.89	1.61
	100	1.51	0.89	1.61
Turbine control valve (TCV) slow closure AND/OR no RPT	0	2.70	0.70	2.70
	25	2.20	0.70	2.20
	25	2.10	0.70	2.10
	80	1.69	0.86	1.95
	80	1.61	0.89	1.84
	100	1.53	0.89	1.63
TCV slow closure/ FHOOS AND/OR no RPT	0	2.85	0.68	2.85
	25	2.35	0.68	2.35
	25	2.14	0.68	2.22
	80	1.69	0.86	1.95
	80	1.61	0.89	1.84
	100	1.53	0.89	1.63
Idle loop startup	0	2.60	0.40	2.60
	25	2.60	0.40	2.60
	25	2.60	0.40	2.60
	60	2.60	0.40	2.60
	100	2.60	0.40	2.60

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[*] Limits support operation with any combination of 1 SRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), up to a 20°F reduction in feedwater temperature (except for conditions with FHOOS), and up to 50% of the LPRMs out of service in the standard, ICF, and MELLLA regions of the power/flow map.

Table 2.2 EOC Base Case $MCPR_p$ Limits and $LHGRFAC_p$ Multipliers for NSS Insertion Times*

EOOS / EOD Condition	Power (% rated)	ATRIUM-9B Fuel		GE9 Fuel
		$MCPR_p$	$LHGRFAC_p$	$MCPR_p$
Base case operation	0	2.70	0.79	2.70
	25	2.20	0.79	2.20
	25	1.89	0.79	1.97
	60	1.44	1.00	1.51
	100	1.39	1.00	1.48

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* Limits support operation with any combination of 1 SRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), up to a 20°F reduction in feedwater temperature (except for conditions with FHOOS), and up to 50% of the LPRMs out of service in the standard, ICF, and MELLLA regions of the power/flow map.

Table 2.3 Coastdown Operation Base Case and EOOS $MCPR_p$ Limits and $LHGRFAC_p$ Multipliers for TSSS Insertion Times*

EOOS / EOD Condition	Power (% rated)	ATRIUM-9B Fuel		GE9 Fuel
		$MCPR_p$	$LHGRFAC_p$	$MCPR_p$
Coastdown base case operation	0	2.70	0.75	2.70
	25	2.20	0.75	2.20
	25	2.05	0.75	2.05
	60	1.48	0.99	1.54
	100	1.42	1.00	1.52
Coastdown with single-loop operation	0	2.71	0.75	2.71
	25	2.21	0.75	2.21
	25	2.06	0.75	2.06
	60	1.49	0.99	1.55
	100	1.43	1.00	1.53
Coastdown with turbine bypass valves out-of-service (TBVOOS)	0	2.70	0.73	2.70
	25	2.20	0.73	2.20
	25	2.05	0.73	2.15
	60	1.55	0.97	1.64
	100	1.44	0.99	1.53
Coastdown with recirculation pump trip out-of-service (no RPT)	0	2.70	0.75	2.70
	25	2.20	0.75	2.20
	25	2.05	0.75	2.05
	60	1.55	0.88	1.67
	100	1.55	0.88	1.67

---

* Limits support operation with any combination of 1 SRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), up to a 20°F reduction in feedwater, and up to 50% of the LPRMs out of service in the standard, ICF, and MELLLA regions of the power/flow map.

Table 2.3 Coastdown Operation Base Case and EOOS $MCPR_p$ Limits and $LHGRFAC_p$ Multipliers for TSSS Insertion Times*

(Continued)

EOOS / EOD Condition	Power (% rated)	ATRIUM-9B Fuel		GE9 Fuel
		$MCPR_p$	$LHGRFAC_p$	$MCPR_p$
Coastdown with turbine control valve (TCV) slow closure AND/OR no RPT	0	2.70	0.68	2.70
	25	2.20	0.68	2.20
	25	2.15	0.68	2.15
	80	1.70	0.85	1.96
	80	1.62	0.88	1.85
	100	1.55	0.88	1.67
Coastdown with idle loop startup	0	2.60	0.40	2.60
	25	2.60	0.40	2.60
	25	2.60	0.40	2.60
	60	2.60	0.40	2.60
	100	2.60	0.40	2.60

---

* Limits support operation with any combination of 1 SRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), up to a 20°F reduction in feedwater temperature, and up to 50% of the LPRMs out of service in the standard, ICF, and MELLLA regions of the power/flow map.

Table 2.4 FFTR/Coastdown Operation Base Case and EOOS $MCPR_p$ Limits and $LHGRFAC_p$ Multipliers for TSSS Insertion Times*

EOOS / EOD Condition	Power (% rated)	ATRIUM-9B Fuel		GE9 Fuel
		$MCPR_p$	$LHGRFAC_p$	$MCPR_p$
FFTR/coastdown base case operation	0	2.85	0.65	2.85
	25	2.35	0.65	2.35
	25	2.30	0.65	2.30
	60	1.56	0.97	1.59
	100	1.42	1.00	1.52
FFTR/coastdown with single-loop operation	0	2.86	0.65	2.86
	25	2.36	0.65	2.36
	25	2.31	0.65	2.31
	60	1.57	0.97	1.60
	100	1.43	1.00	1.53
FFTR/coastdown with turbine bypass valves out-of-service (TBVOOS)	0	2.85	0.65	2.85
	25	2.35	0.65	2.35
	25	2.30	0.65	2.30
	60	1.57	0.97	1.64
	100	1.44	0.99	1.53
FFTR/coastdown with recirculation pump trip out-of-service (no RPT)	0	2.85	0.65	2.85
	25	2.35	0.65	2.35
	25	2.30	0.65	2.30
	60	1.56	0.88	1.67
	100	1.55	0.88	1.67

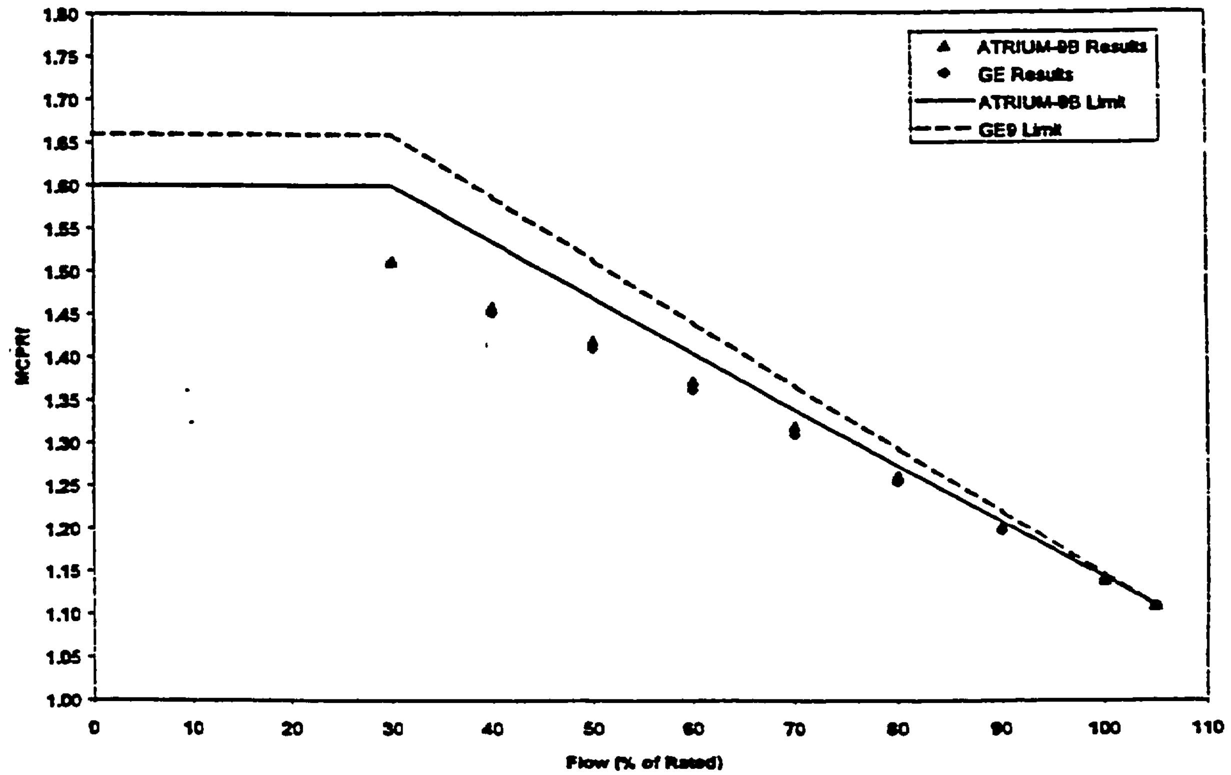
---

* Limits support operation with any combination of 1 SRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out of service in the standard, ICF, and MELLLA regions of the power/flow map.

Table 2.4 FFTR/Coastdown Operation Base Case and EOOS $MCPR_p$ Limits and $LHGRFAC_p$ Multipliers for TSSS Insertion Times*
(Continued)

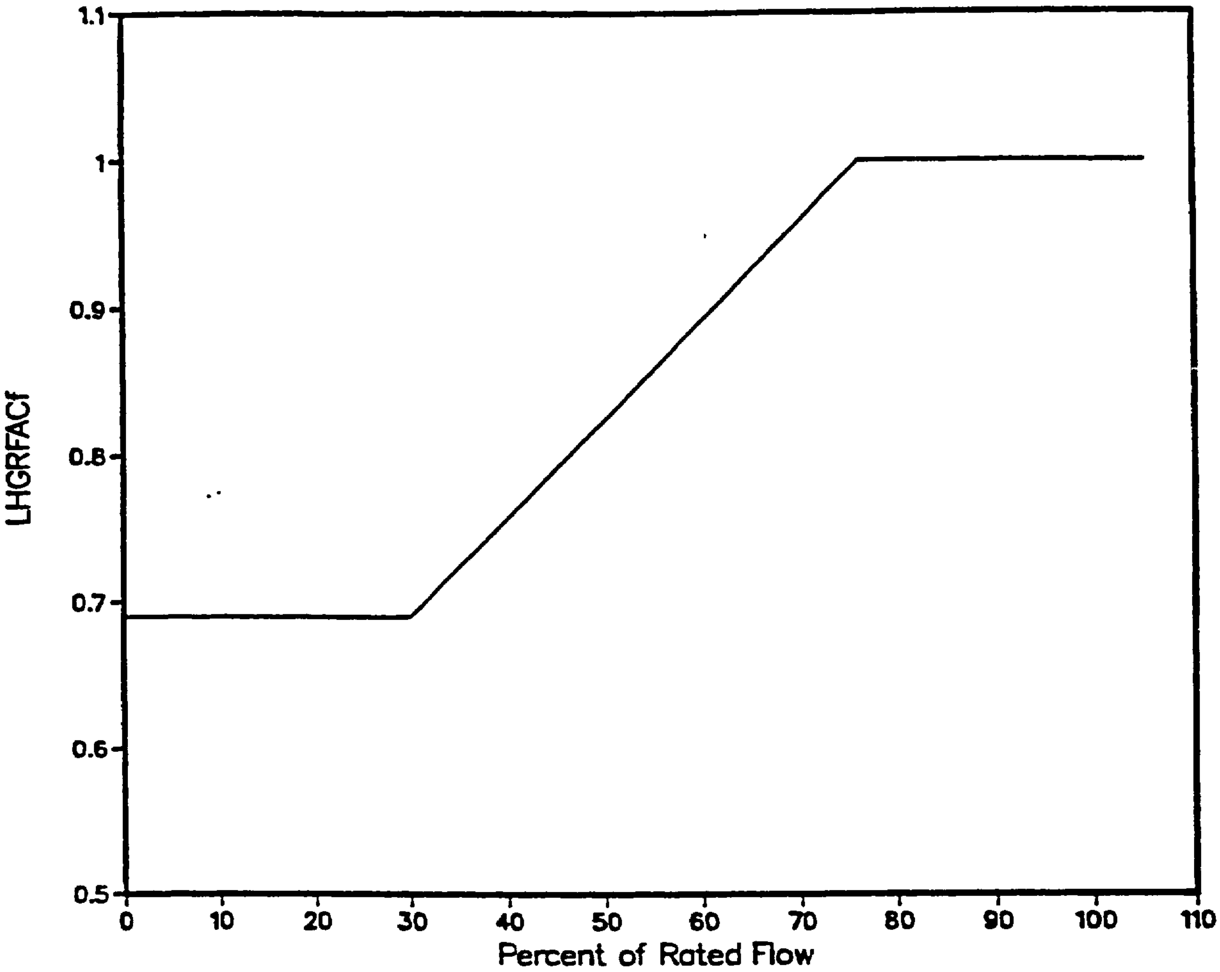
EOOS / EOD Condition	Power (% rated)	ATRIUM-9B Fuel		GE9 Fuel
		$MCPR_p$	$LHGRFAC_p$	$MCPR_p$
FFTR/coastdown with turbine control valve (TCV) slow closure AND/OR no RPT	0	2.85	0.65	2.85
	25	2.35	0.65	2.35
	25	2.30	0.65	2.30
	80	1.70	0.85	1.96
	80	1.62	0.88	1.85
	100	1.55	0.88	1.67
FFTR/coastdown with idle loop startup	0	2.60	0.40	2.60
	25	2.60	0.40	2.60
	25	2.60	0.40	2.60
	60	2.60	0.40	2.60
	100	2.60	0.40	2.60

- Limits support operation with any combination of 1 SRVOOS, up to 2 TIPOOS (or the equivalent number of TIP channels), and up to 50% of the LPRMs out of service in the standard, ICF, and MELLLA regions of the power/flow map.



Flow (% of rated)	MCPR_f ATRIUM-9B	MCPR_f GE9 (penalty included)
0	1.60	1.66
30	1.60	1.66
105	1.11	1.11

Figure 2.1 Flow-Dependent MCPR Limits for Manual Flow Control Mode



Flow (% rated)	$LHGRFAC_f$
0	0.69
30	0.69
76	1.00
105	1.00

Figure 2.2 Flow-Dependent LHGRFAC Multipliers for ATRIUM-9B Fuel

3.0 Transient Analysis for Thermal Margin - Base Case Operation

This section describes the analyses performed to determine the power- and flow-dependent MCPR and LHGR operating limits for base case operation at LaSalle Unit 2 Cycle 9.

COTRANSA2 (Reference 4), XCOBRA-T (Reference 11), XCOBRA (Reference 7) and CASMO-3G/MICROBURN-B (Reference 3) are the major codes used in the thermal limits analyses as described in SPC's THERMEX methodology report (Reference 7) and neutronics methodology report (Reference 3). COTRANSA2 is a system transient simulation code, which includes an axial one-dimensional neutronics model that captures the effects of axial power shifts associated with the system transients. XCOBRA-T is a transient thermal-hydraulics code used in the analysis of thermal margins for the limiting fuel assembly. XCOBRA is used in steady-state analyses. The ANFB critical power correlation (Reference 6) is used to evaluate the thermal margin of the fuel assemblies. Calculations have been performed to demonstrate the applicability of the ANFB critical power correlation to GE9 fuel at LaSalle using the Reference 12 methodology. Fuel pellet-to-cladding gap conductance values are based on RODEX2 (Reference 13) calculations for the LaSalle Unit 2 Cycle 9 core configuration.

3.1 *System Transients*

System transient calculations have been performed to establish thermal limits to support L2C9 operation. Reference 9 identifies the potential limiting events that need to be evaluated on a cycle-specific basis. The potentially limiting transients for which SPC has analysis responsibility are the LRNB and FWCF events. Other transient events are either bound by the consequences of one of the limiting transients, or are part of ComEd's analysis responsibility.

Reactor plant parameters for the system transient analyses are shown in Table 3.1 for the 100% power/100% flow conditions. Additional plant parameters used in the analyses are presented in Reference 8. Analyses have been performed to determine power-dependent MCPR and LHGR limits that protect operation throughout the power/flow domain depicted in Figure 1.1. At LaSalle, direct scram and recirculation pump high- to low-speed transfer on turbine stop valve (TSV) and turbine control valve (TCV) position are bypassed at power levels less than 25% of rated. Reference 14 indicates that MCPR and LHGR limits need to be monitored at power levels greater than or equal to 25% of rated. As a result, all analyses used to establish base case $MCPR_p$ limits and $LHGRFAC_p$ multipliers are performed with both direct scram and RPT operable for power levels at or above 25% of rated.

The limiting exposure for rated power pressurization transients is at end of full power (EOFP) when the control rods are fully withdrawn. Off-rated power analyses were performed at earlier cycle exposures to ensure that the operating limits provide the necessary protection.

All pressurization transients assumed only the 11 highest set point safety relief valves (SRVs) were operable, consistent with the discussion in Section 7. In order to support operation with 1 SRV out-of-service, the pressurization transient analyses were performed with the lowest set point SRV out-of-service, which makes a total of 10 SRVs available.

The term, recirculation pump trip (RPT), is used synonymously with recirculation pump high- to low-speed transfer as it applies to pressurization transients. During the high- to low-speed transfer, the recirculation pumps trip off line and coast. When they reach the low-speed setting, the pumps reengage at the low speed. The time it takes for the pumps to coast to the low-speed condition is much longer than the duration of the pressurization transients. Therefore, a recirculation pump trip has the same effect on pressurization transients as a recirculation pump high- to low-speed transfer.

Reductions in feedwater temperature of less than 20°F from the nominal feedwater temperature are considered base case operation, not an EOOS condition. As discussed in Reference 9, the reduced feedwater temperature is limiting for FWCF transients. As a result, the base case FWCF results are based on a 20°F reduction in feedwater temperature.

The results of the system pressurization transients are sensitive to the scram speed used in the calculations. To take advantage of scram speeds faster than the TSSS insertion times presented in Reference 14 scram speed-specific $MCPR_p$ limits and $LHGRFAC_p$ multipliers are provided. The NSS insertion times used in the analyses reported are presented in Reference 8 and reproduced in Table 3.2. The NSS $MCPR_p$ limits and $LHGRFAC_p$ multipliers can only be applied if the scram speed surveillance tests meet the NSS insertion times. System transient analyses were performed to establish $MCPR_p$ limits and $LHGRFAC_p$ multipliers for base case operation for both NSS and TSSS insertion times.

3.1.1 Load Rejection No Bypass

The load rejection causes a fast closure of the turbine control valve. The resulting compression wave travels through the steam lines into the vessel and creates a rapid pressurization. The increase in pressure causes a decrease in core void, which in turn causes a rapid increase in power. The fast closure of the turbine control valve also causes a reactor scram and a recirculation pump high- to low-speed transfer which helps mitigate the pressurization effects. Turbine bypass system operation, which also mitigates the consequences of the event, is not credited. The excursion of the core power due to the void collapse is terminated primarily by the reactor scram and revoiding of the core. The analysis assumes 3-element feedwater level control; however, manual- or single-element feedwater level control will not significantly affect thermal limit or pressure results.

The generator load rejection without turbine bypass system (LRNB) is a more limiting transient than the turbine trip no bypass (TTNB) transient. The initial position of the TCV is such that it closes faster than the turbine stop valve. This more than makes up for any differences in the scram signal delays between the two events. This has been demonstrated in calculations that support the Reference 9 conclusion that the TTNB event is bound by the LRNB event.

LRNB analyses were performed for several power/flow conditions to support generation of the thermal limits. Table 3.3 presents the LRNB transient results for both TSSS and NSS insertion times for Cycle 9. For illustration, Figures 3.1–3.3 are presented to show the responses of various reactor and plant parameters during the LRNB event initiated at 100% of rated power and 105% of rated core flow with TSSS insertion times.

3.1.2 Feedwater Controller Failure

The increase in feedwater flow due to a failure of the feedwater control system to maximum demand results in an increase in the water level and a decrease in the coolant temperature at the core inlet. The increase in core inlet subcooling causes an increase in core power. As the feedwater flow continues at maximum demand, the water level will continue to rise and eventually reaches the high water level trip set point. The initial water level is conservatively assumed to be at the lower level operating range at 30 inches above instrument zero to delay the high level trip and maximize the core inlet subcooling that results from the FWCF. The high water level trip causes the turbine stop valves to close in order to prevent damage to the turbine from excessive liquid inventory in the steam line. The valve closures create a compression wave that travels to the core causing a void collapse and subsequent rapid power excursion. The closure of the turbine valves initiates a reactor scram and a recirculation pump high- to low-speed transfer. In addition, the turbine bypass valves are assumed operable and provide some pressure relief. The core power excursion is mitigated in part by the pressure relief, but the primary mechanisms for termination of the event are reactor scram and revoiding of the core.

FWCF analyses were performed for several power/flow conditions to support generation of the thermal limits. Table 3.4 presents the base case FWCF transient results for both TSSS and NSS insertion times for Cycle 9. For illustration, Figures 3.4–3.6 are presented to show the responses of various reactor and plant parameters during the FWCF event initiated at 100% of rated power and 105% of rated core flow with TSSS insertion times.

3.1.3 Loss-of-Feedwater Heating

ComEd has the analysis responsibility for the loss-of-feedwater heating (LFWH) event at rated conditions. At reactor power levels less than rated, the LFWH event is less limiting than the LFWH event at rated conditions for the following reasons:

- At lower power/flow conditions with other core conditions such as control rod patterns and exposure unchanged, the initial MCPR is higher than the MCPR at rated power and flow. This results in additional MCPR margin to the MCPR safety limit.
- The possible change in feedwater temperature during an LFWH event decreases as the reactor power decreases.

3.2 *MCPR Safety Limit*

The MCPR safety limit is defined as the minimum value of the critical power ratio at which the fuel can be operated, with the expected number of rods in boiling transition not exceeding 0.1% of the fuel rods in the core. The MCPR safety limit for all fuel in the LaSalle Unit 2 Cycle 9 core was determined using the methodology described in Reference 5. The effects of channel bow on core limits are determined using a statistical procedure. The mean channel bow is determined from the exposure of the fuel channels and measured channel bow data. CASMO-3G is used to determine the effect on the local peaking factor distribution. Once the channel bow effects on the local peaking factors are determined, the impact on the core limits is determined in the MCPR safety limit analysis. Further discussion of how the effects of channel bow are accounted for is presented in Reference 5. The main input parameters and uncertainties used in the safety limit analysis are listed in Table 3.5. The radial power uncertainty includes the effects of up to 2 TIPOOS or the equivalent number of TIP channels (100% available at startup), up to 50% of the LPRMs out-of-service, and an LPRM calibration interval of 2500 EFPH as discussed in References 16 and 24. The channel bow local peaking uncertainty is a function of the nominal and bowed local peaking factors and the standard deviation of the measured bow data.

The determination of the safety limit explicitly includes the effects of channel bow and relies on the following assumptions:

- Cycle 9 will not contain channels used for more than one fuel bundle lifetime.
- The channel exposure at discharge will not exceed 48,000 MWd/MTU based on the fuel bundle average exposure.
- The Cycle 9 core contains all CarTech-supplied channels.

Analyses were performed with input parameters (including the radial power and local peaking factor distributions) consistent with each exposure step in the design basis step-through. The analysis that produced the highest number of rods in boiling transition corresponds to a Cycle 9 exposure of 15,000 MWd/MTU. The radial power distribution corresponding to a Cycle 9 exposure of 15,000 MWd/MTU is shown in Figure 3.7. Eight fuel types were represented in the LaSalle Unit 2 Cycle 9 safety limit analysis: four SPC ATRIUM-9B fuel types loaded in Cycle 9 (SPCA9-391B-14G8.0-100M, SPCA9-410B-19G8.0-100M, SPCA9-383B-16G8.0-100M, and SPCA9-396B-12GZ-100M); two ATRIUM-9B fuel types loaded in Cycle 8 (SPCA9-381B-13GZ7-80M and SPCA9-384B-11GZ6-80M); and two GE9 fuel types loaded in Cycle 7 (GE9B-P8CWB322-11GZ-100M-150 and GE9B-P8CWB320-9GZ-100M-150).

The local power peaking factors, including the effects of channel bow, at 70% void and assembly exposures consistent with a Cycle 9 exposure of 15,000 MWd/MTU are presented in Figures 3.8 through 3.11 for the Cycle 9 SPC ATRIUM-9B fuel. The bowed local peaking factor data used in the MCPR safety limit analysis for fuel type SPCA9-391B-14G8.0-100M is at an assembly average exposure of 18,000 MWd/MTU. The data for fuel types SPCA9-410B-19G8.0-100M and SPCA9-383B-16G8.0-100M is at an assembly average exposure of 17,500 MWd/MTU. The data is at an assembly average exposure of 15,000 MWd/MTU for fuel type SPCA9-396B-12GZ-100M.

The results of the analysis support a two-loop operation MCPR safety limit of 1.11 and a single-loop operation MCPR safety limit of 1.12 for all fuel types in the Cycle 9 core. These results are applicable for all EOD and EOOS conditions presented in Table 1.1 and support startup with uncalibrated LPRMs for an exposure range of BOC to 500 MWd/MTU .

3.3 *Power-Dependent MCPR and LHGR Limits*

Figures 3.12 and 3.13 present the base case operation TSSS ATRIUM-9B and GE9 $MCPR_p$ limits for Cycle 9. Figures 3.14 and 3.15 present the ATRIUM-9B and GE9 $MCPR_p$ limits for base case operation with NSS insertion times. The limits are based on the ΔCPR results from the limiting system transient analyses discussed above and a MCPR safety limit of 1.11.

Relative to the TSSS $MCPR_p$ limits, using the faster NSS insertion times provide lower $MCPR_p$ limits.

The pressurization transient analyses provide the necessary information to determine appropriate multipliers on the fuel design LHGR limit for ATRIUM-9B fuel to support off-rated power operation. Application of the $LHGRFAC_p$ multipliers to the steady-state LHGR limit ensures that the LHGR during AOOs initiated at reduced power does not exceed the PAPT limits. The method used to calculate the $LHGRFAC_p$ multipliers is presented in Appendix A. The results of the LRNB and FWCF analyses discussed above were used to determine the base case $LHGRFAC_p$ multipliers. The base case ATRIUM-9B $LHGRFAC_p$ multipliers for Cycle 9 TSSS and NSS insertion times are presented in Figures 3.16 and 3.17, respectively.

3.4 *Flow-Dependent MCPR and LHGR Limits*

Flow-dependent MCPR and LHGR limits are established to support operation at off-rated core flow conditions. The limits are based on the CPR and heat flux changes experienced by the fuel during slow flow excursions. The slow flow excursion event assumes a failure of the recirculation flow control system such that the core flow increases slowly to the maximum flow physically attainable by the equipment. An uncontrolled increase in flow creates the potential for a significant increase in core power and heat flux. A conservatively steep flow run-up path was determined starting at a low-power/low-flow state point of 58.1%P/30%F increasing to the high-power/high-flow state point of 124.2%P/105%F.

$MCPR_f$ limits are determined for the manual flow control (MFC) mode of operation for both ATRIUM-9B and GE9 fuel. XCOBRA is used to calculate the change in critical power ratio during a two-loop flow run-up to the maximum flow rate. The $MCPR_f$ limit is set so that the increase in core power resulting from the maximum increase in core flow is such that the MCPR safety limit of 1.11 is not violated. Calculations were performed for several initial flow rates to determine the corresponding MCPR values that put the limiting assembly on the MCPR safety limit at the high-flow condition at the end of the flow excursion.

Results of the MFC flow run-up analysis are presented in Table 3.6 for both the ATRIUM-9B and GE9 fuel. $MCPR_f$ limits that provide the required protection during MFC operation are presented in Figure 2.1. The Cycle 9 $MCPR_f$ limits were established such that they support base case operation and operation in the EOD, EOOS, and combined EOD/EOOS scenarios. The $MCPR_f$ limits are valid for all exposure conditions during Cycle 9. Since a low- to high-speed pump upshift is required to attain high-flow rates, for initial core flows less than 30% of rated, the limit is conservatively set equal to the 30% flow value. The $MCPR_f$ penalty described in Reference 10 has been applied to the GE9 $MCPR_f$ limits shown in Figure 2.1. The penalty is a function of core flow with a value of 0.0 at 100% of rated and increases linearly to 0.05 at 40% of rated. The penalty continues to increase to 30% of rated core flow where a penalty of 0.06 is applied.

SPC has performed $LHGRFAC_f$ analyses with the CASMO-3G/MICROBURN-B core simulator codes. The analysis assumes that the recirculation flow increases slowly along the limiting rod line to the maximum flow physically attainable by the equipment. A series of flow excursion analyses were performed at several exposures throughout the cycle starting from different initial power/flow conditions. Xenon is assumed to remain constant during the event. The $LHGRFAC_f$ multipliers were established to ensure that the LHGR during the flow run-up does not violate the PAPT LHGR limit. Since a low- to high-speed pump upshift is required to attain high-flow rates, for initial core flows less than 30% of rated, the $LHGRFAC_f$ multiplier is conservatively set equal to the 30% flow value. The $LHGRFAC_f$ values as a function of core flow for the ATRIUM-9B fuel are presented in Figure 2.2. The Cycle 9 $LHGRFAC_f$ multipliers were established to support base case operation and operation in the EOD, EOOS, and combined EOD/EOOS scenarios for all Cycle 9 exposure conditions.

3.5 *Nuclear Instrument Response*

The impact of loading ATRIUM-9B fuel into the LaSalle core will not affect the nuclear instrument response. The neutron lifetime is an important parameter affecting the time response of the incore detectors. The neutron lifetime is a function of the nuclear and mechanical design of the fuel assembly, the in-channel void fraction, and the fuel exposure. The neutron lifetimes are similar for the SPC and GE LaSalle fuel with typical values of $39(10^{-6})$ to $40(10^{-6})$ seconds for the ATRIUM-9B lattices and $41(10^{-6})$ to $43(10^{-6})$ seconds for the GE9 lattices as calculated with the CASMO-3G code at core average void and exposure conditions. Therefore, the neutron lifetimes for a full core of ATRIUM-9B fuel, a mixed core of ATRIUM-9B and GE9 fuel, and a full core of GE9 fuel are essentially equivalent.

Table 3.1 LaSalle Unit 2 Plant Conditions at Rated Power and Flow

Reactor thermal power	3489 MWt
Total core flow	108.5 Mlbm/hr
Core active flow	93.7 Mlbm/hr
Core bypass flow*	14.8 Mlbm/hr
Core inlet enthalpy	523.9 Btu/lbm
Vessel pressures	
Steam dome	1001 psia
Core exit (upper-plenum)	1013 psia
Lower-plenum	1038 psia
Turbine pressure	948 psia
Feedwater / steam flow	15.145 Mlbm/hr
Feedwater enthalpy	406.6 Btu/lbm
Recirculating pump flow (per pump)	15.83 Mlbm/hr
Core average gap coefficient (EOC)	1162 Btu/hr-ft^2-°F

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* Includes water channel flow.

Table 3.2 Scram Speed Insertion Times

Control Rod Position (notch)	TSSS Time (sec)	NSS Time (sec)
48 (*full-out*)	0.000	0.000
48*	0.200*	0.200*
45	0.430	0.380
39	0.860	0.680
25	1.930	1.680
5	3.490	2.680
0 (*full-in*)	3.880	2.804

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* As indicated in Reference 8, the delay between scram signal and control rod motion is conservatively modeled. Sensitivity analyses indicate that using no delay provides slightly conservative results (Reference 22).

Table 3.3 EOC Base Case LRNB Transient Results

Power/ Flow	ATRIUM-9B ΔCPR	ATRIUM-9B LHGRFAC_p	GE9 ΔCPR	Peak Neutron Flux (% rated)	Peak Heat Flux (% rated)
TSSS Insertion Times					
100 / 105	0.30	1.01	0.40	422	127
100 / 100	0.29	1.01	0.39	431	128
100 / 81	0.28	1.01	0.38	437	126
80 / 105	0.29	1.04	0.39	324	100
80 / 57.2	0.29	1.05	0.39	265	96
60 / 105	0.27	1.06	0.36	245	73
60 / 35.1	0.17	1.13	0.21	96	63
40 / 105	0.23*	1.13	0.27	100*	46*
25 / 105	0.17*	1.22*	0.19*	44*	27*
NSS Insertion Times					
100 / 105	0.28	1.02	0.37	380	124
100 / 81	0.22	1.03	0.30	358	120
80 / 105	0.27	1.04	0.36	302	98
80 / 57.2	0.20	1.09	0.26	218	90
60 / 105	0.26	1.07	0.35	236	73
60 / 35.1	0.13	1.18	0.14	76	60
40 / 105	0.20	1.14	0.27	115	47
25 / 105	0.15*	1.22	0.17	42*	27*

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[*] The analysis results are from an earlier cycle exposure. The ΔCPR and LHGRFAC_p results are conservatively used to establish the thermal limits.

Table 3.4 EOC Base Case FWCF Transient Results

Power/ Flow	ATRIUM-9B ΔCPR	ATRIUM-9B $LHGRFAC_p$	GE9 ΔCPR	Peak Neutron Flux (% rated)	Peak Heat Flux (% rated)
TSSS Insertion Times					
100 / 105	0.25	1.09	0.31	298	123
100 / 100	0.24	1.11	0.31	288	122
100 / 81	0.23	1.09	0.28	285	121
80 / 105	0.28	1.07	0.35	253	101
80 / 57.2	0.19	1.16	0.23	154	91
60 / 105	0.35*	1.02*	0.41	154*	77*
60 / 35.1	0.11	1.25	0.14	74	63
40 / 105	0.51*	0.94*	0.57*	104*	58*
25 / 105	0.80*	0.79*	0.88*	69*	44*
NSS Insertion Times					
100 / 105	0.23	1.10	0.29	263	120
100 / 81	0.18	1.11	0.22	237	116
80 / 105	0.27	1.10	0.33	235	99
80 / 57.2	0.15	1.20	0.17	131	88
60 / 105	0.33	1.05*	0.40	188	79
60 / 35.1	0.11	1.28	0.13	65	63
40 / 105	0.48*	0.95*	0.55*	96*	57*
25 / 105	0.78*	0.79*	0.86*	66*	44*

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* The analysis results are from an earlier cycle exposure. The ΔCPR and $LHGRFAC_p$ results are conservatively used to establish the thermal limits.

Table 3.5 Input for MCPR Safety Limit Analysis

Fuel-Related Uncertainties

Parameter	Source Document	Statistical Treatment
ANFB correlation*		
ATRIUM-9B GE9	Reference 17 Reference 12	Convoluted Convoluted
Radial power	References 16 and 21	Convoluted
Local peaking factor	Reference 5	Convoluted
Assembly flow rate (mixed core)	Reference 5	Convoluted
Channel bow local peaking	Function of nominal and bowed local peaking and standard deviation of bow data (see Reference 18)	Convoluted

Nominal Values and
Plant Measurement Uncertainties

Parameter	Value	Uncertainty (%) (Reference 8)	Statistical Treatment
Feedwater flow rate† (Mlbm/hr)	22.4	1.76	Convoluted
Feedwater temperature (°F)	426.5	0.76	Convoluted
Core pressure (psia)	1031.35	0.50	Convoluted
Total core flow (Mlbm/hr)	113.9	2.50	Convoluted
Core power† (MWth)	5167.29	—	—

---

* Additive constant uncertainties values are used.

† Feedwater flow rate and core power were increased above design values to attain desired core MCPR for safety limit evaluation consistent with Reference 5 methodology

Table 3.6 Flow-Dependent MCPR Results

Core Flow (% rated)	105% Maximum Core Flow	
	GE9	ATRIUM-9B
30	1.52	1.52
40	1.46	1.46
50	1.41	1.42
60	1.37	1.38
70	1.31	1.32
80	1.26	1.27
90	1.20	1.21
100	1.14	1.14
105	1.11	1.11

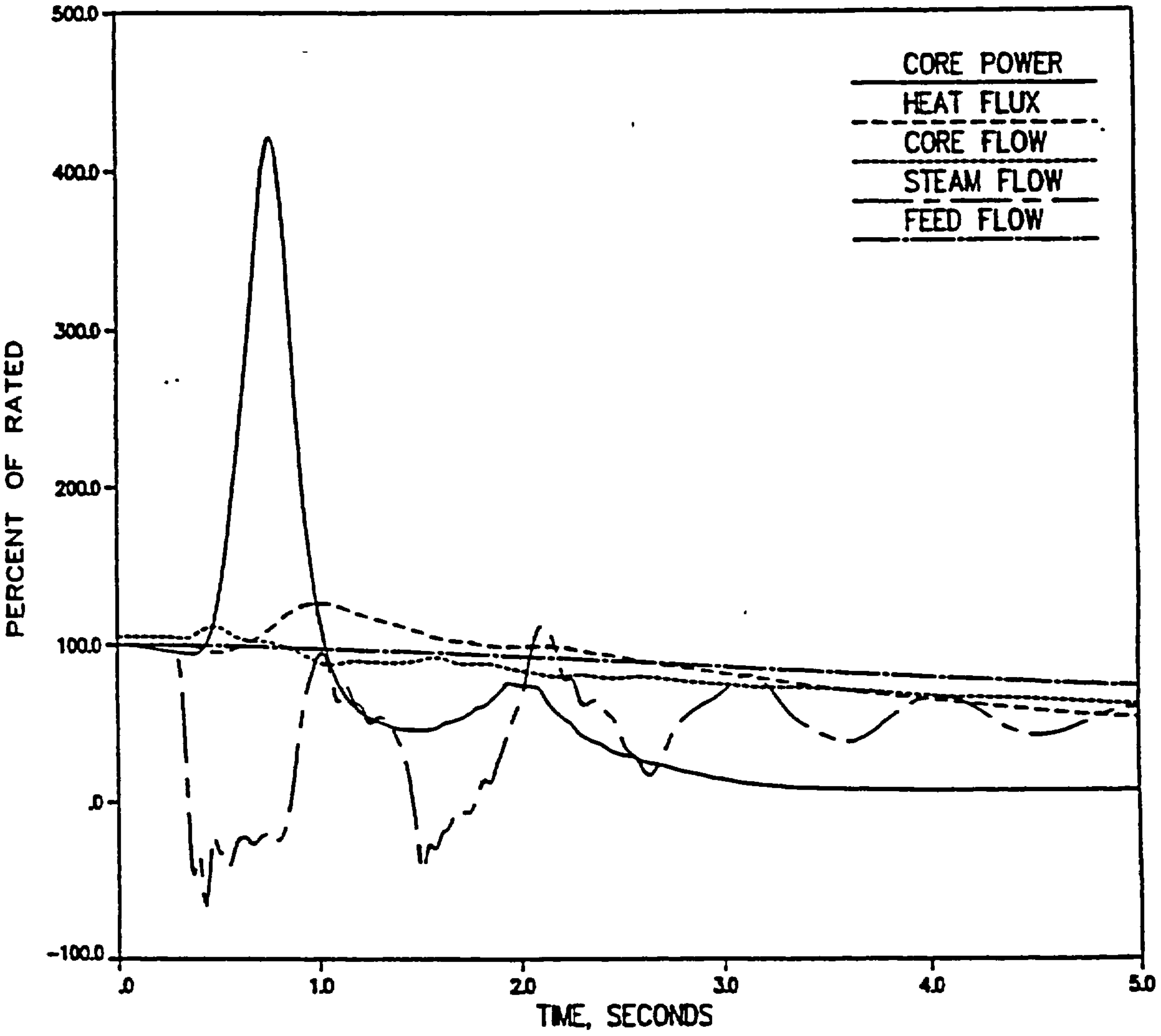


Figure 3.1 EOC Load Rejection No Bypass at 100/105 – TSSS Key Parameters

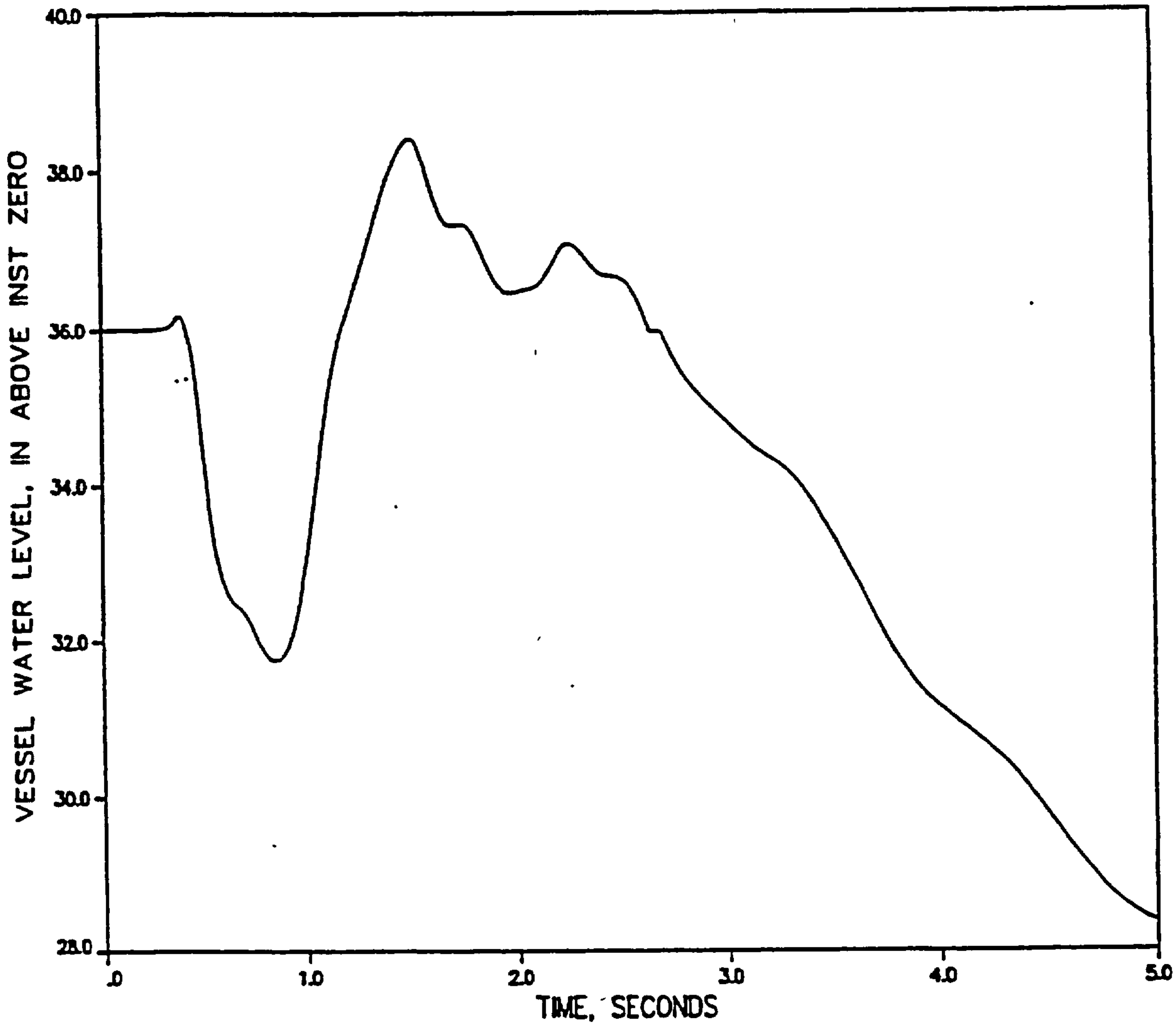


Figure 3.2 EOC Load Rejection No Bypass at 100/105 – TSSS Vessel Water Level

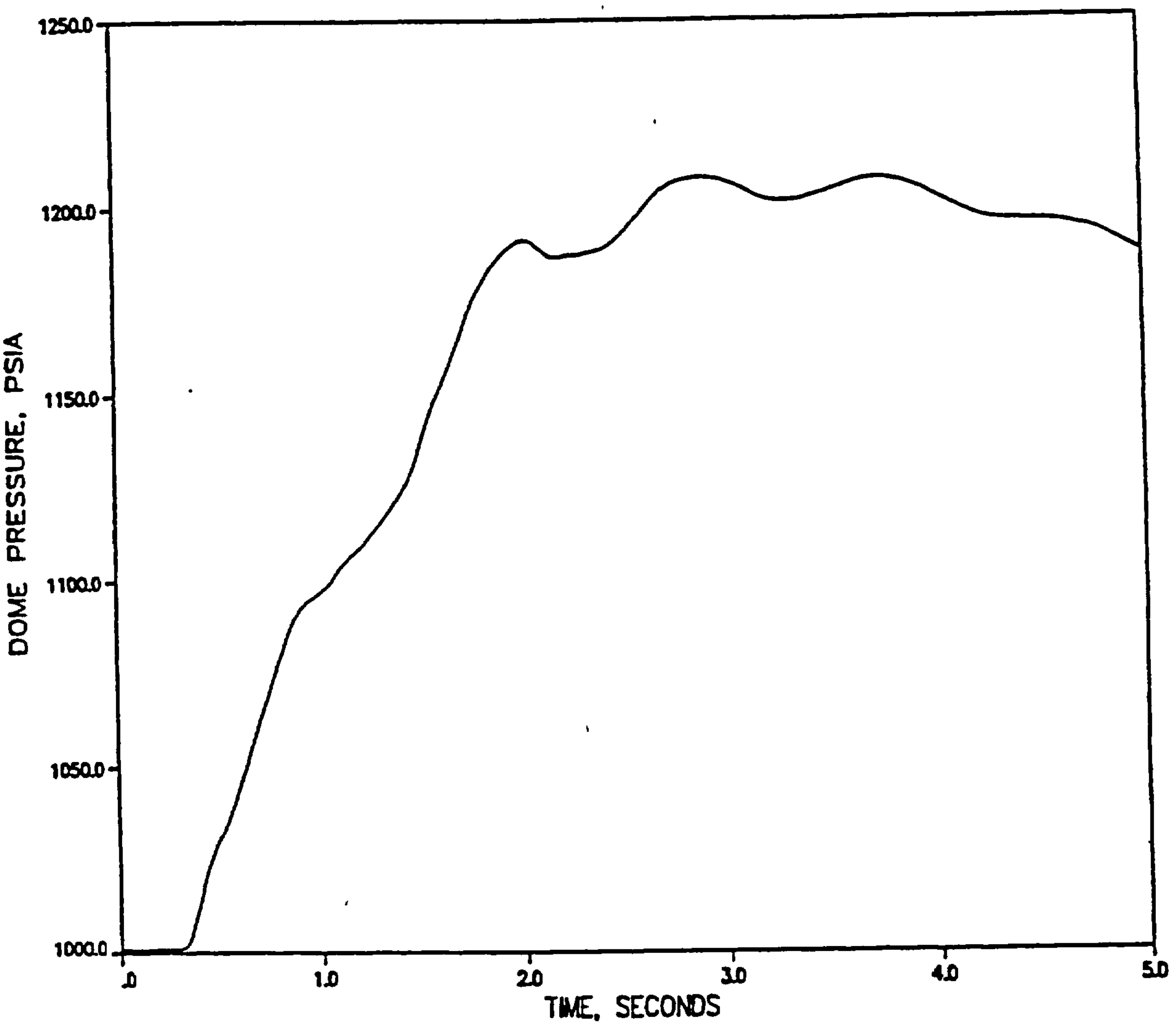


Figure 3.3 EOC Load Rejection No Bypass at 100/105 – TSSS Dome Pressure

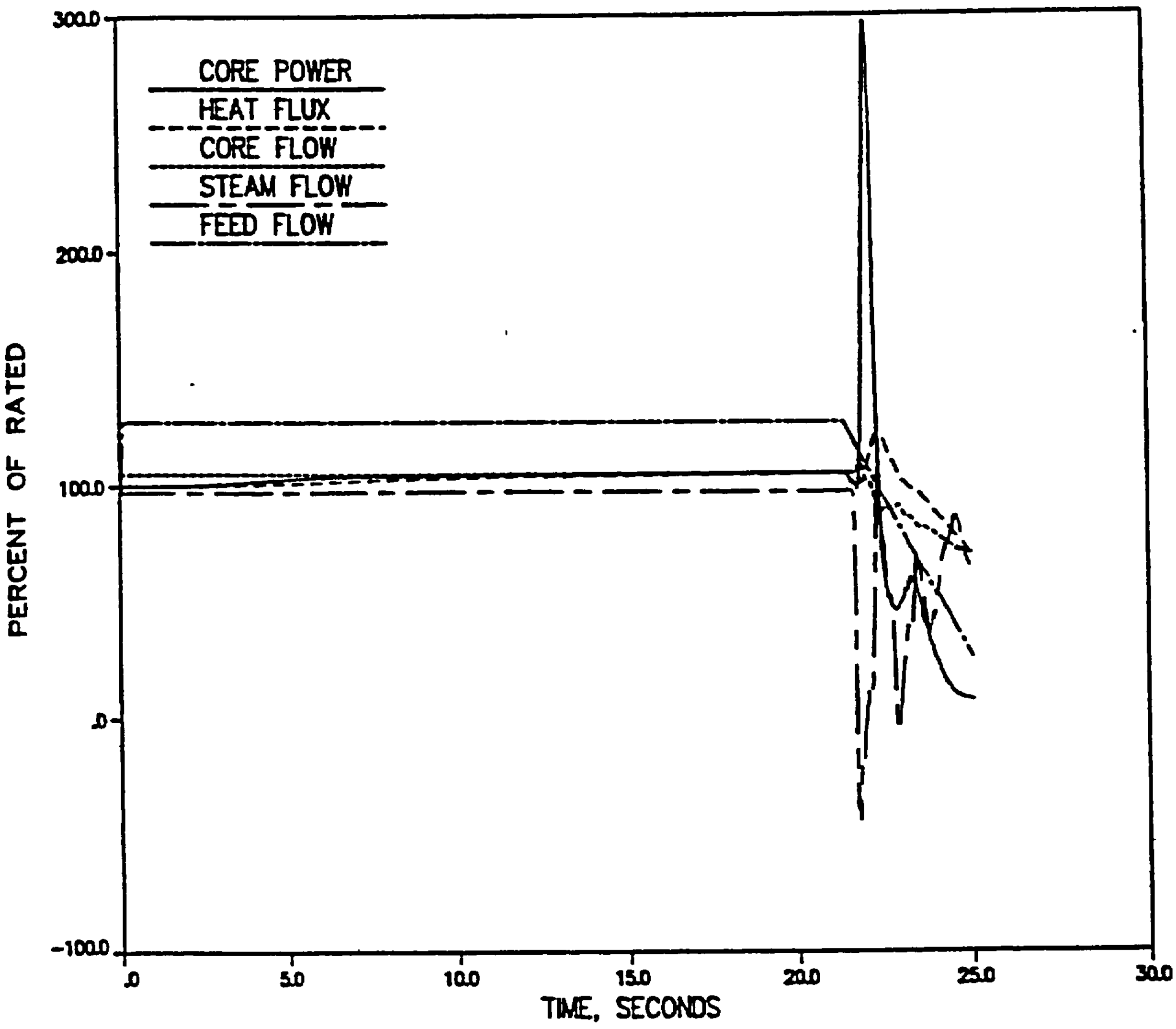


Figure 3.4 EOC Feedwater Controller Failure at 100/105 – TSSS Key Parameters

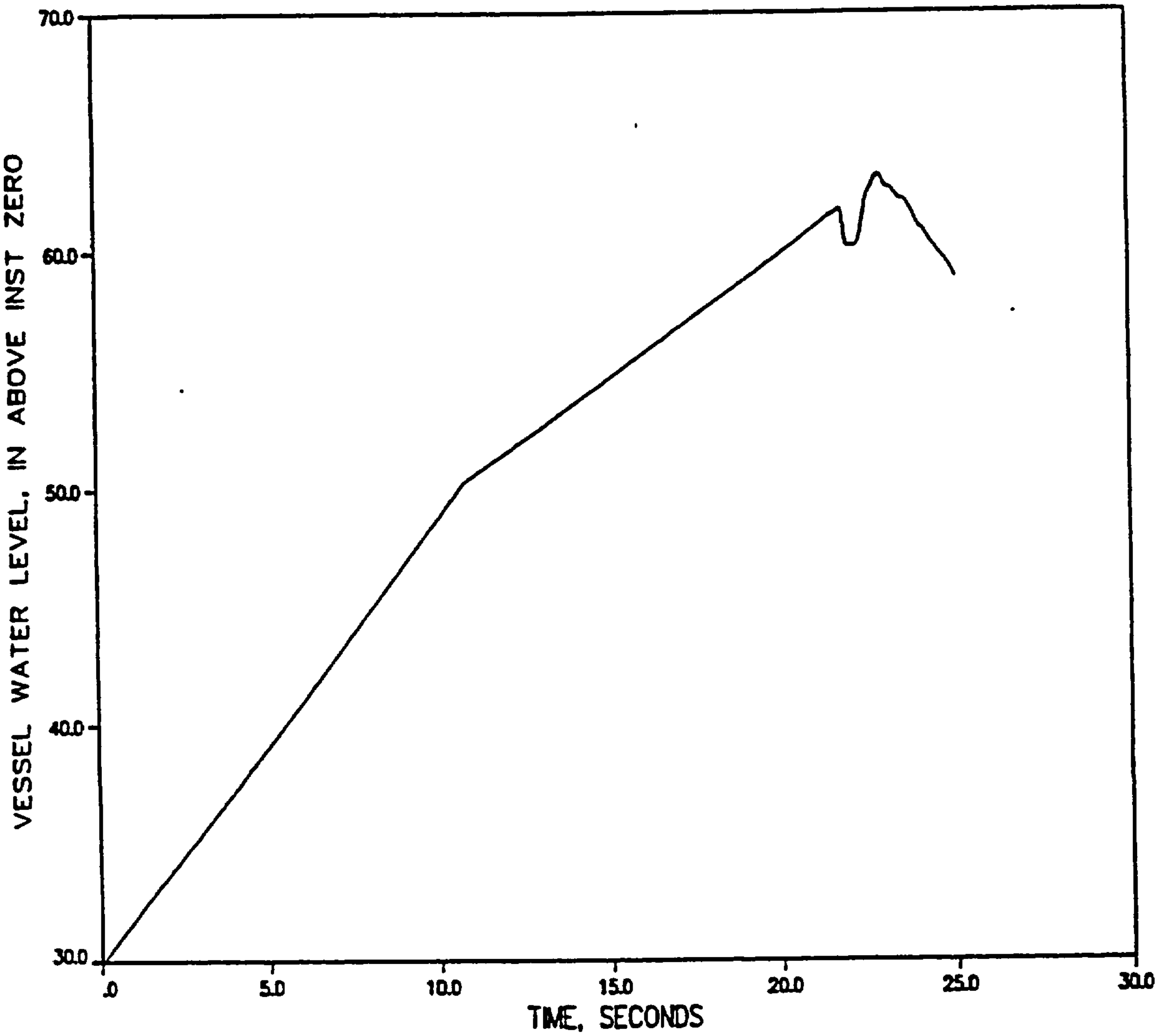


Figure 3.5 EOC Feedwater Controller Failure at 100/105 – TSSS Vessel Water Level

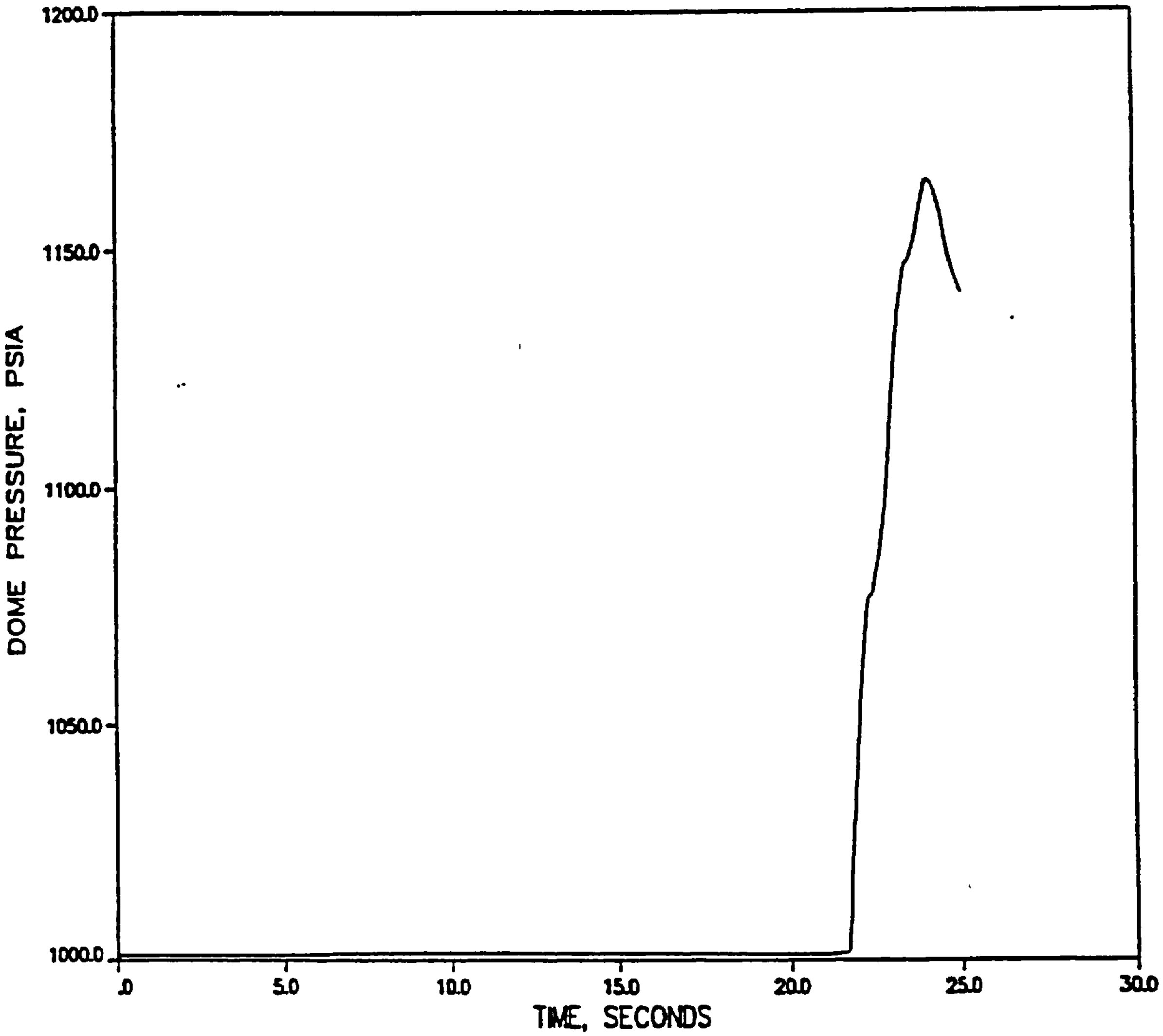


Figure 3.6 EOC Feedwater Controller Failure at 100/105 – TSSS Dome Pressure

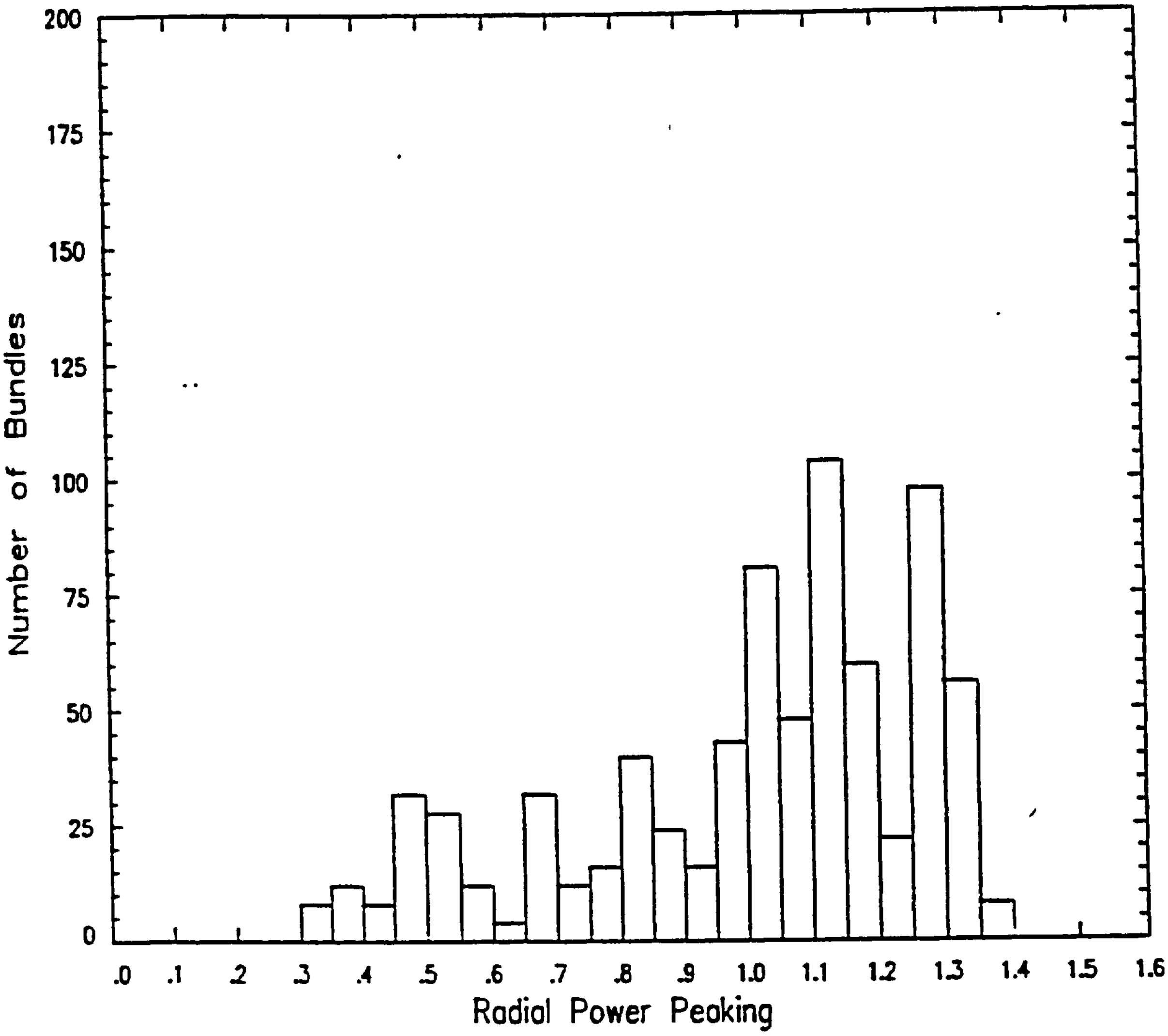


Figure 3.7 Radial Power Distribution for SLMCPR Determination

Control Rod Corner

Control Rod Corner

1.052	1.045	1.088	1.088	1.104	1.079	1.068	1.013	1.005
1.045	0.951	1.019	0.996	0.852	0.986	0.998	0.914	0.991
1.088	1.019	1.001	1.059	1.089	1.051	0.982	0.981	1.027
1.088	0.996	1.059	Internal Water Channel			0.905	0.957	1.050
1.104	0.852	1.089				1.068	0.807	1.035
1.079	0.986	1.051				1.025	0.942	1.039
1.068	0.998	0.982	0.905	1.068	1.025	0.811	0.954	1.005
1.013	0.914	0.981	0.957	0.807	0.942	0.954	0.874	0.957
1.005	0.991	1.027	1.050	1.035	1.039	1.005	0.957	0.956

Figure 3.8 LaSalle Unit 2 Cycle 9
Safety Limit Local Peaking Factors
SPCA9-391B-14G8.0-100M With Channel Bow
(Assembly Exposure of 18,000 MWd/MTU)

Control Rod Corner

Control Rod Corner

1.058	1.049	1.092	1.091	1.107	1.082	1.072	1.017	1.010
1.049	0.945	1.020	0.996	0.843	0.987	0.998	0.906	0.995
1.092	1.020	1.002	1.061	1.090	1.052	0.981	0.980	1.030
1.091	0.996	1.061	Internal Water Channel			0.894	0.955	1.053
1.107	0.843	1.090				1.067	0.797	1.036
1.082	0.987	1.052				1.024	0.941	1.041
1.072	0.998	0.981	0.894	1.067	1.024	0.800	0.952	1.007
1.017	0.906	0.980	0.955	0.797	0.941	0.952	0.865	0.960
1.010	0.995	1.030	1.053	1.036	1.041	1.007	0.960	0.960

**Figure 3.9 LaSalle Unit 2 Cycle 9
Safety Limit Local Peaking Factors
SPCA9-410B-19G8.0-100M With Channel Bow
(Assembly Exposure of 17,500 MWd/MTU)**

Control Rod Corner

Control Rod Corner

1.017	1.017	1.068	1.083	1.107	1.074	1.048	0.985	0.970
1.017	0.986	1.024	1.000	0.885	0.992	1.004	0.956	0.965
1.068	1.024	0.890	1.063	1.091	1.055	0.990	0.989	1.009
1.083	1.000	1.063	Internal Water Channel			0.944	0.966	1.055
1.107	0.885	1.091				1.074	0.846	1.040
1.074	0.992	1.055				1.032	0.951	1.043
1.048	1.004	0.990	0.944	1.074	1.032	0.850	0.964	0.988
0.985	0.956	0.989	0.966	0.846	0.951	0.964	0.916	0.932
0.970	0.965	1.009	1.055	1.040	1.043	0.988	0.932	0.924

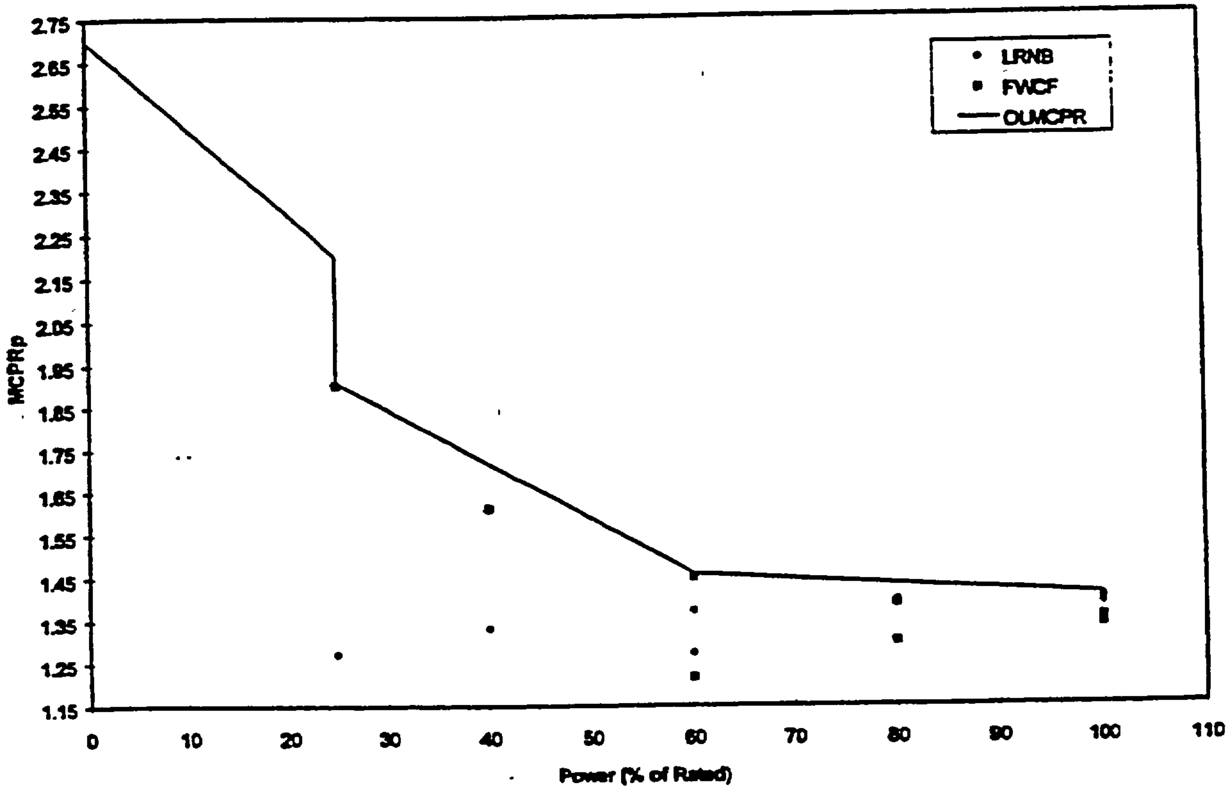
Figure 3.10 LaSalle Unit 2 Cycle 9
Safety Limit Local Peaking Factors
SPCA9-383B-16G8.0-100M With Channel Bow
(Assembly Exposure of 17,500 MWd/MTU)

Control Rod Corner

Control Rod Corner

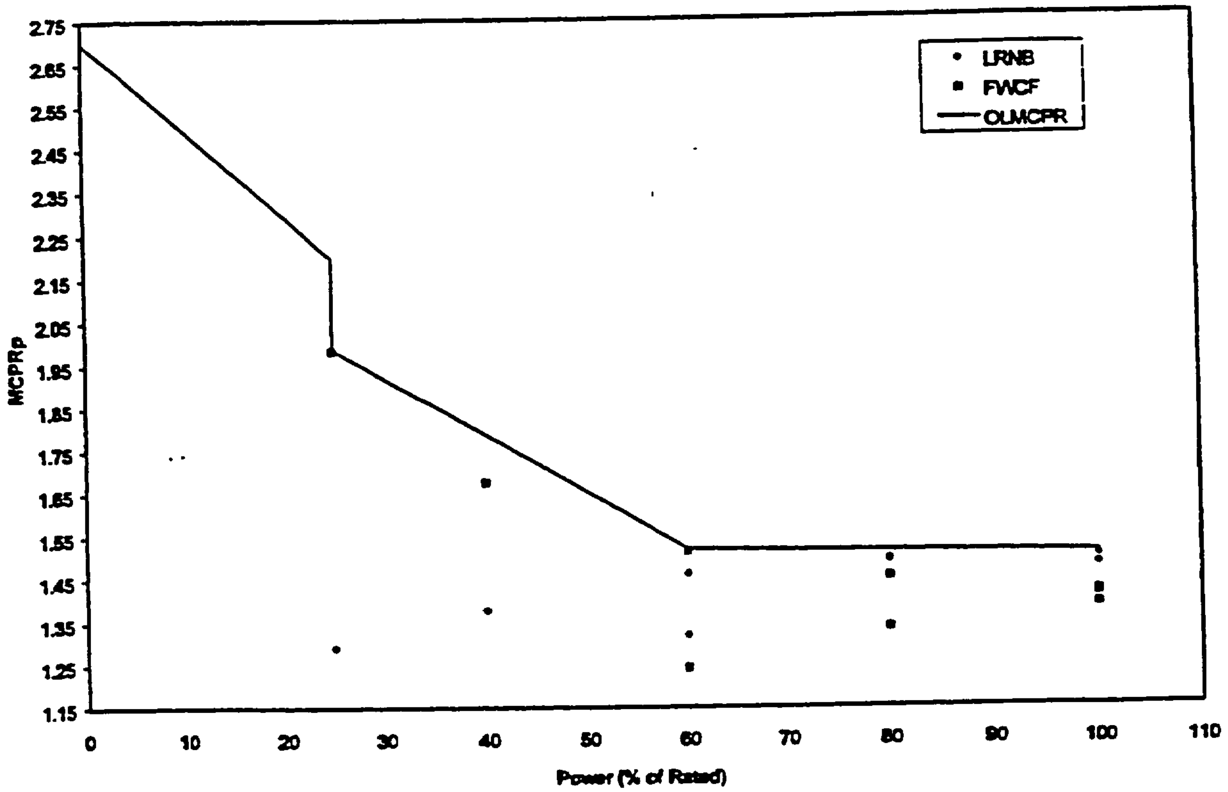
1.025	1.058	1.062	1.117	1.100	1.108	1.043	1.026	0.979
1.058	0.934	1.018	0.852	1.003	0.845	0.999	0.903	1.005
1.062	1.018	1.003	1.067	1.092	1.058	0.984	0.983	1.006
1.117	0.852	1.067	Internal Water Channel			1.046	0.823	1.056
1.100	1.003	1.092				1.072	0.968	1.039
1.108	0.845	1.058				1.038	0.816	1.046
1.043	0.999	0.984	1.046	1.072	1.038	0.965	0.963	0.986
1.026	0.903	0.983	0.823	0.968	0.816	0.963	0.873	0.973
0.979	1.005	1.006	1.056	1.039	1.046	0.986	0.973	0.933

Figure 3.11 LaSalle Unit 2 Cycle 9
Safety Limit Local Peaking Factors
SPCA9-396B-12GZ-100M With Channel Bow
(Assembly Exposure of 15,000 MWdMTU)



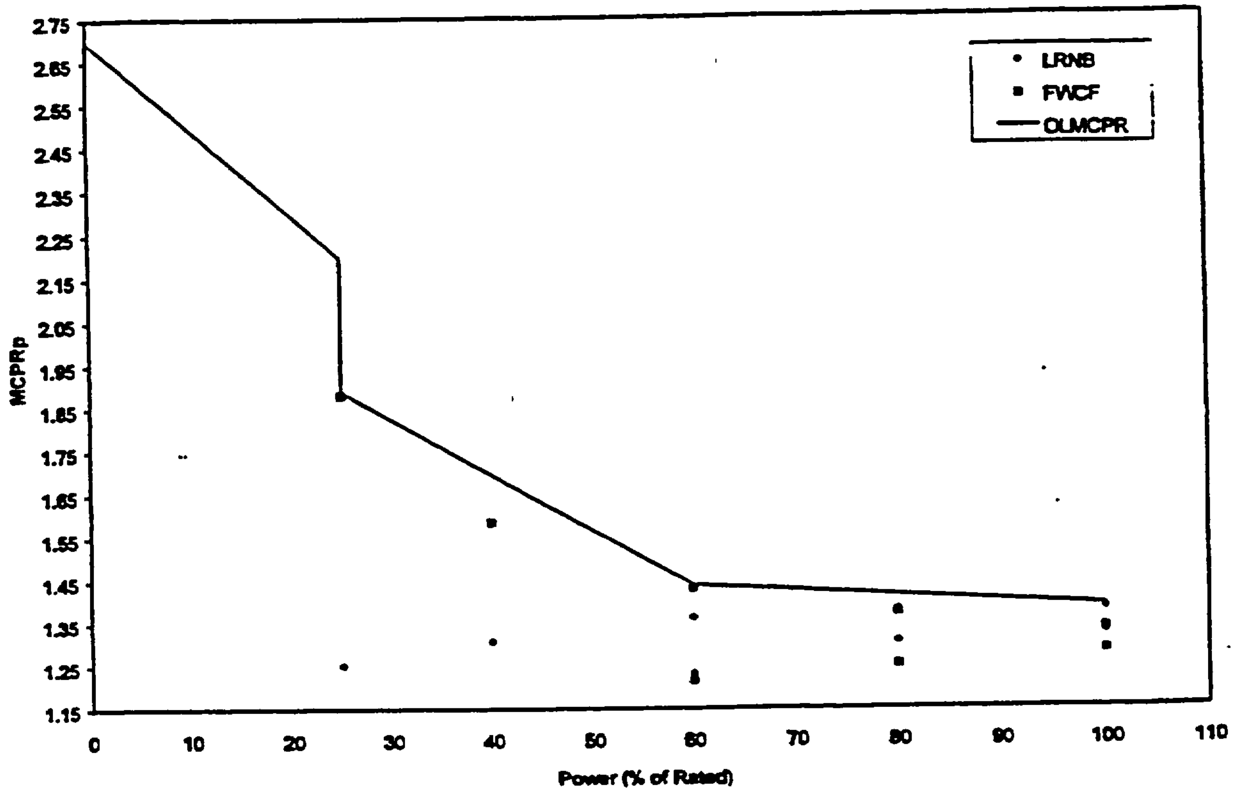
Power (%)	$MCPR_p$ Limit
100	1.41
60	1.46
25	1.91
25	2.20
0	2.70

Figure 3.12 EOC Base Case Power-Dependent MCPR Limits for ATRUM-9B Fuel – TSSS Insertion Times



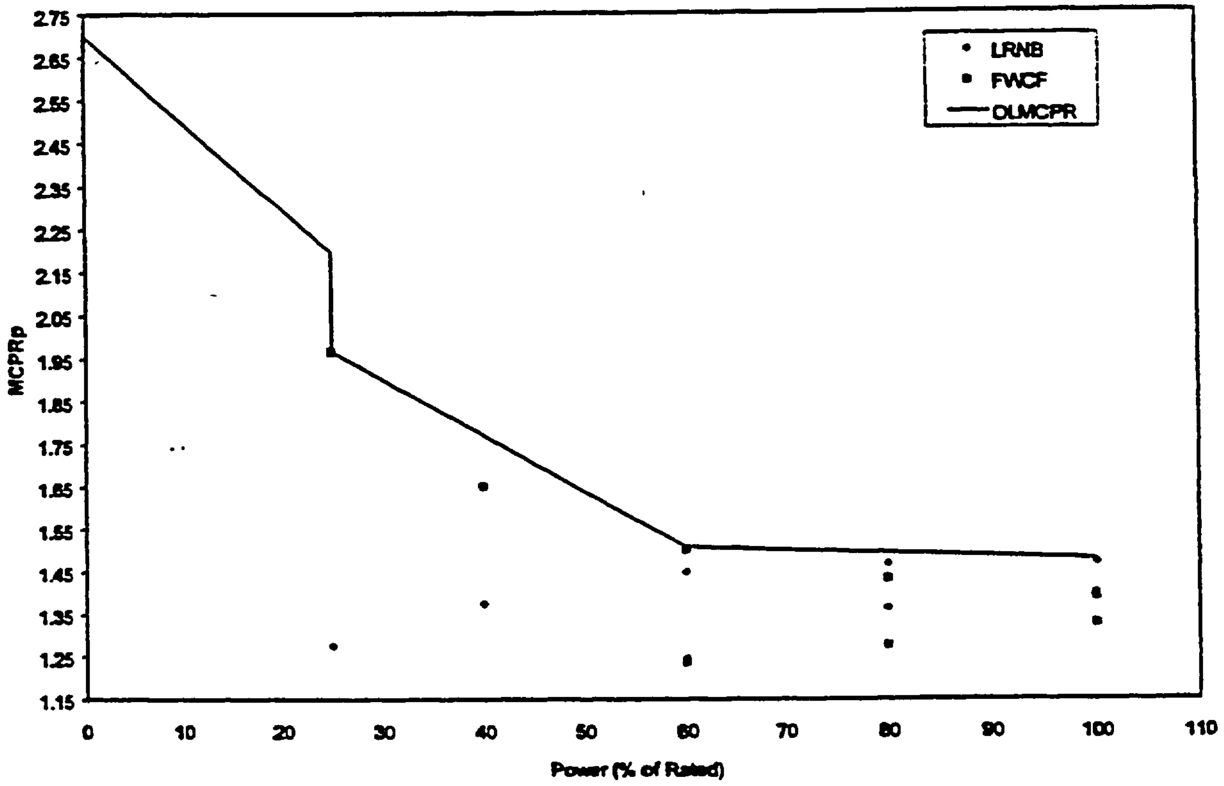
Power (%)	$MCPR_p$ Limit
100	1.51
60	1.52
25	1.99
25	2.20
0	2.70

Figure 3.13 EOC Base Case Power-Dependent MCPR Limits for GE9 Fuel – TSSS Insertion Times



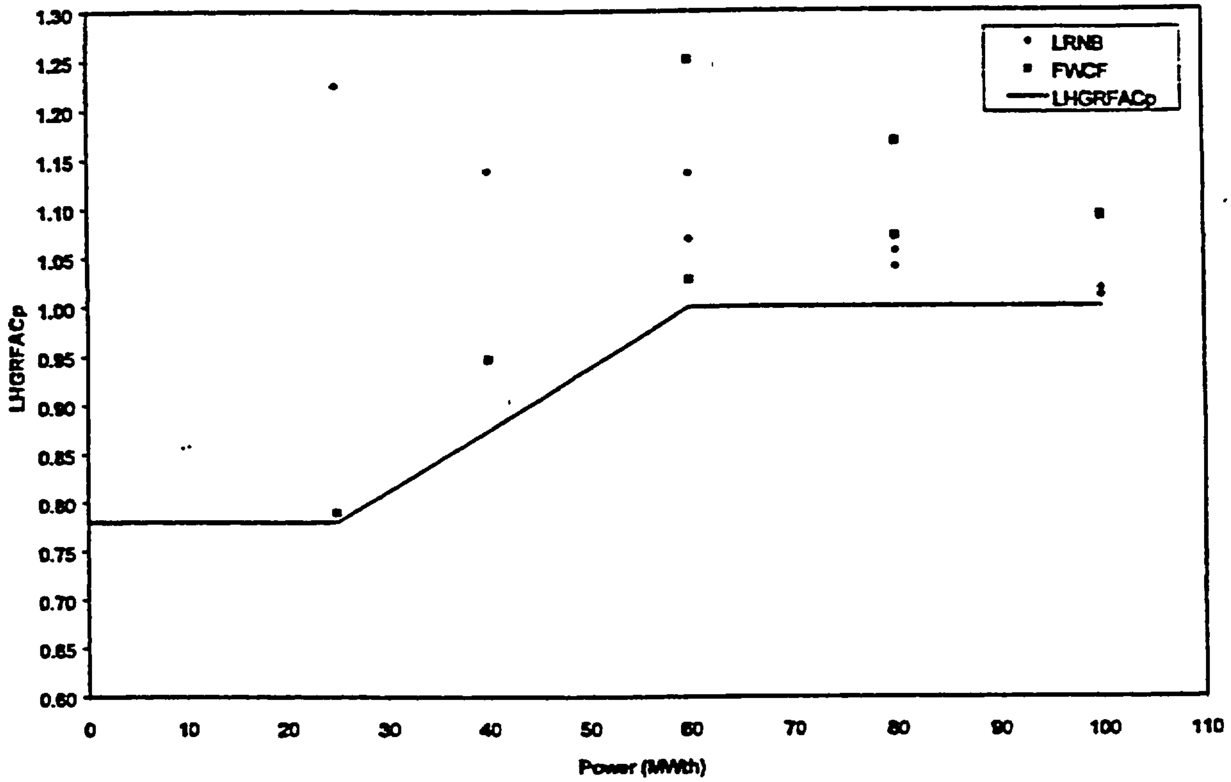
Power (%)	$MCPR_p$ Limit
100	1.39
60	1.44
25	1.89
25	2.20
0	2.70

Figure 3.14 EOC Base Case Power-Dependent MCPR Limits for ATRUM-9B Fuel – NSS Insertion Times



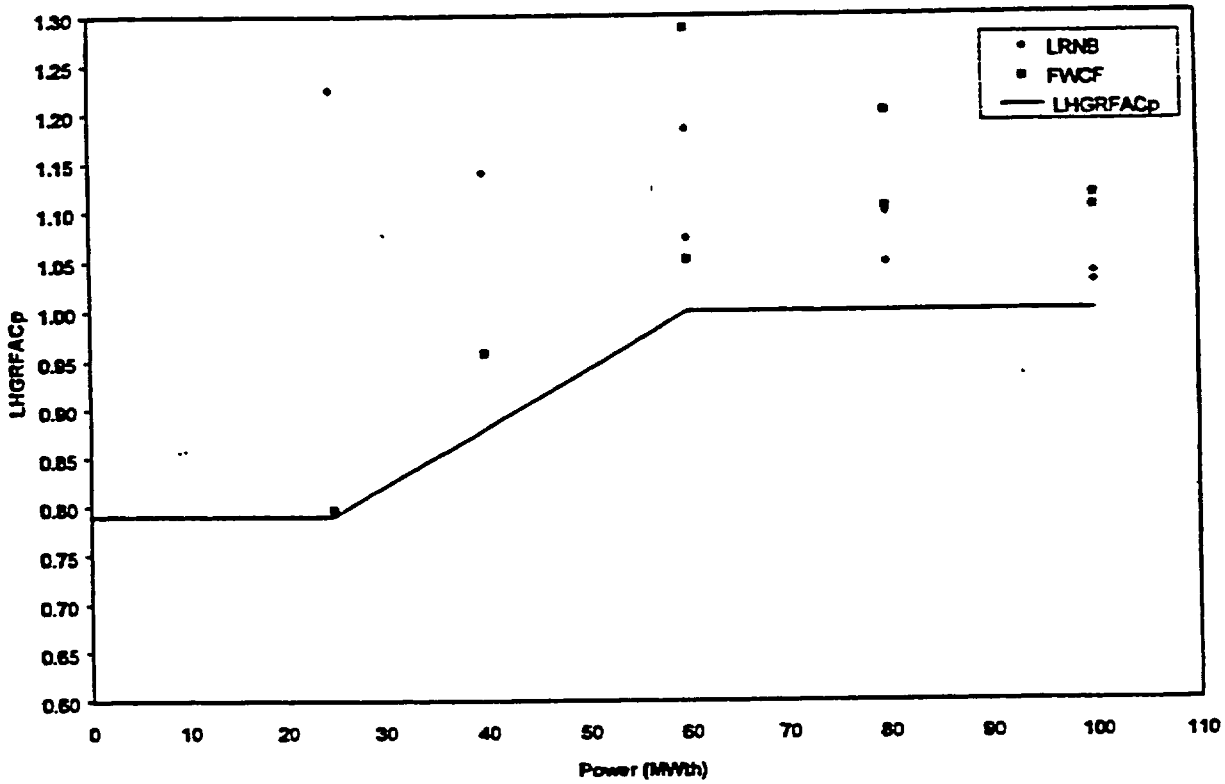
Power (%)	$MCPR_p$ Limit
100	1.48
60	1.51
25	1.97
25	2.20
0	2.70

Figure 3.15 EOC Base Case Power-Dependent MCPR Limits for GE9 Fuel – NSS Insertion Times



Power (%)	LHGRFAC$_p$ Multiplier
100	1.00
60	1.00
25	0.78
25	0.78
0	0.78

Figure 3.16 EOC Base Case Power-Dependent LHGR Multipliers for ATRUM-9B Fuel – TSSS Insertion Times



Power (%)	LHGRFAC$_p$ Multiplier
100	1.00
60	1.00
25	0.79
25	0.79
0	0.79

Figure 3.17 EOC Base Case Power-Dependent LHGR Multipliers for ATRUM-9B Fuel – NSS Insertion Times

4.0 Transient Analysis for Thermal Margin - Extended Operating Domain

This section describes the development of the MCPR and LHGR limits to support operation in the following extended operating domains:

- Increased core flow (ICF) to 105% of rated flow.
- Power coastdown to 40% of rated power.
- Final feedwater temperature reduction (FFTR) of up to 100°F and with ICF. Since FFTR is typically used in connection with coastdown, analyses were performed to support combined FFTR/coastdown operation.

Results of the limiting transient analyses are used to determine appropriate MCPR$_p$ limits and LHGRFAC$_p$ multipliers for ATRIUM-9B and GE9 fuel to support operation in the EOD scenarios. MCPR$_p$ limits are established for both ATRIUM-9B and GE9 fuel while LHGRFAC$_p$ multipliers are only established for the ATRIUM-9B fuel.

As discussed in Reference 9, the MCPR safety limit analysis for the base case remains valid for operation in the EODs discussed below. Also, the flow-dependent MCPR and LHGR analyses described in Section 3.4 were performed such that the results are applicable for all the EODs.

4.1 *Increased Core Flow*

The base case analyses presented in Section 3.0 were performed to support operation in the power/flow domain presented in Figure 1.1, which includes operation in the ICF region. The coastdown and combined FFTR/coastdown analyses are performed in conjunction with ICF to conservatively maximize the exposure at which a given power level can be attained. As a result, the analyses performed support operation in the ICF extended operating domain for all exposures.

4.2 *Coastdown Analysis*

Coastdown analyses were performed to ensure that appropriate MCPR$_p$ limits and LHGRFAC$_p$ multipliers are applied to support coastdown operation. The analyses were performed for coastdown operation to 40% of rated power using a conservative coastdown rate equivalent to a 10% decrease in rated power per 1000 MWd/MTU increase in exposure. An additional 1000 MWd/MTU was added to the EOFP exposure prior to the start of coastdown to provide operation support for operation at up to 10% of rated power above the equilibrium xenon coastdown power level. The MCPR$_p$ limits and LHGRFAC$_p$ multipliers are based on results of

LRNB and FWCF analyses. The analyses were performed at cycle exposures consistent with the assumed coastdown rate. This corresponds to the highest exposure at which the power can be obtained. The base case coastdown ΔCPRs for both the ATRIUM-9B and GE9 fuel as well as the ATRIUM-9B $LHGRFAC_p$ results are presented in Table 4.1 for the indicated power/flow conditions. The ATRIUM-9B $MCPR_p$ limits and $LHGRFAC_p$ multipliers for coastdown operation are presented in Figures 4.1 and 4.2. The GE9 coastdown $MCPR_p$ limits are presented in Figure 4.3.

4.3 *Combined Final Feedwater Temperature Reduction/Coastdown*

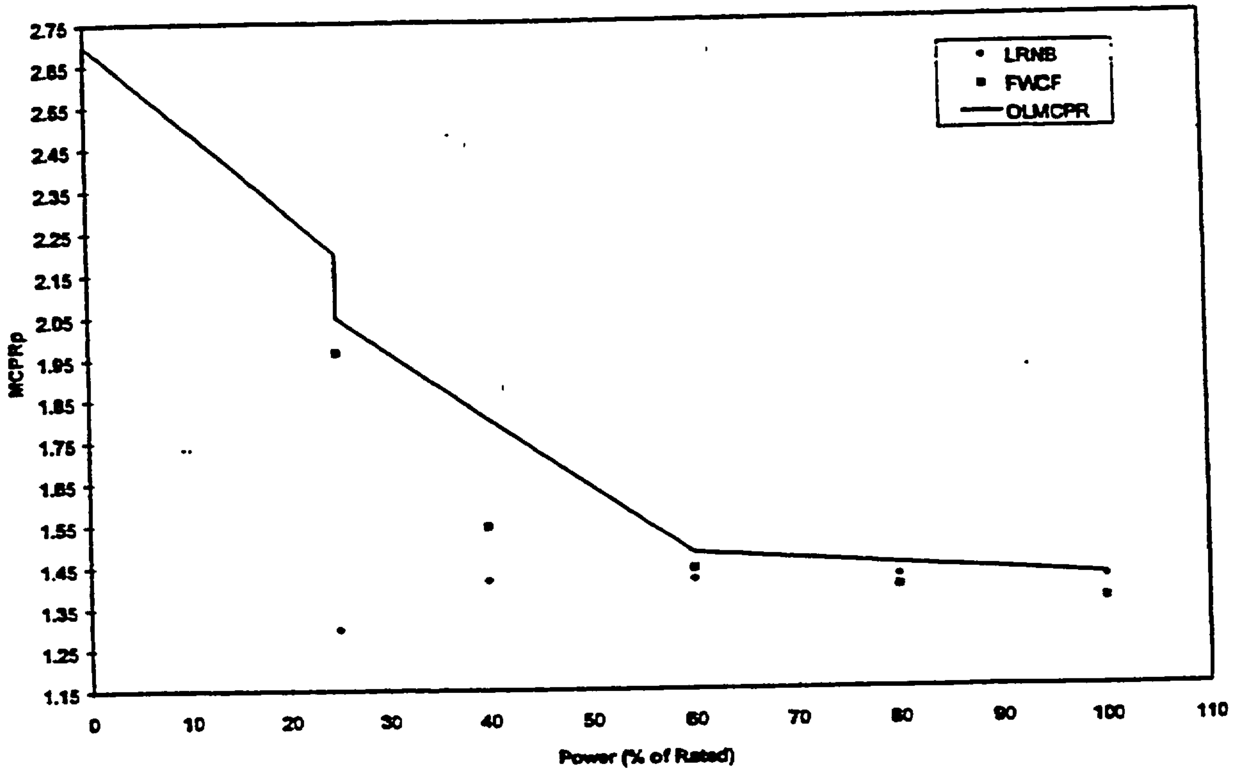
Analyses were performed to support FFTR with thermal coastdown to ensure that appropriate $MCPR_p$ limits and $LHGRFAC_p$ multipliers are established. The combined FFTR/coastdown analysis used a 100°F feedwater temperature reduction applied at EOFP to extend full thermal power operation. The coastdown exposure extension discussed in Section 4.2 (1000 MWd/MTU to support operation at up to 10% of rated power above the equilibrium xenon power level) was then applied. LRNB and FWCF analyses were performed to establish $MCPR_p$ limits and $LHGRFAC_p$ multipliers. The Cycle 9 FFTR/coastdown ΔCPR results for both ATRIUM-9B and GE9 fuel as well as the $LHGRFAC_p$ results are presented in Table 4.2 for the indicated power flow conditions. The ATRIUM-9B $MCPR_p$ limits and $LHGRFAC_p$ multipliers for combined FFTR/coastdown operation are presented in Figures 4.4 and 4.5. The GE9 coastdown $MCPR_p$ limits are presented in Figure 4.6.

Table 4.1 Coastdown Operation Transient Results

Event	Power/ Flow (% rated / % rated)	ATRIUM		GE9
		ΔCPR	LHGRFAC$_p$	ΔCPR
LRNB	100 / 105	0.31	1.00	0.41
LRNB	80 / 105	0.32	1.00	0.35
LRNB	60 / 105	0.31	0.99	0.35
LRNB	40 / 105	0.31	0.96	0.31
LRNB	25 / 105	0.19	1.13	0.19
FWCF	100 / 105	0.26	1.08	0.32
FWCF	80 / 105	0.29	1.08	0.31
FWCF	60 / 105	0.34	1.08	0.36
FWCF	40 / 105	0.44	1.12	0.44
FWCF	25 / 105	0.86	1.08	0.88

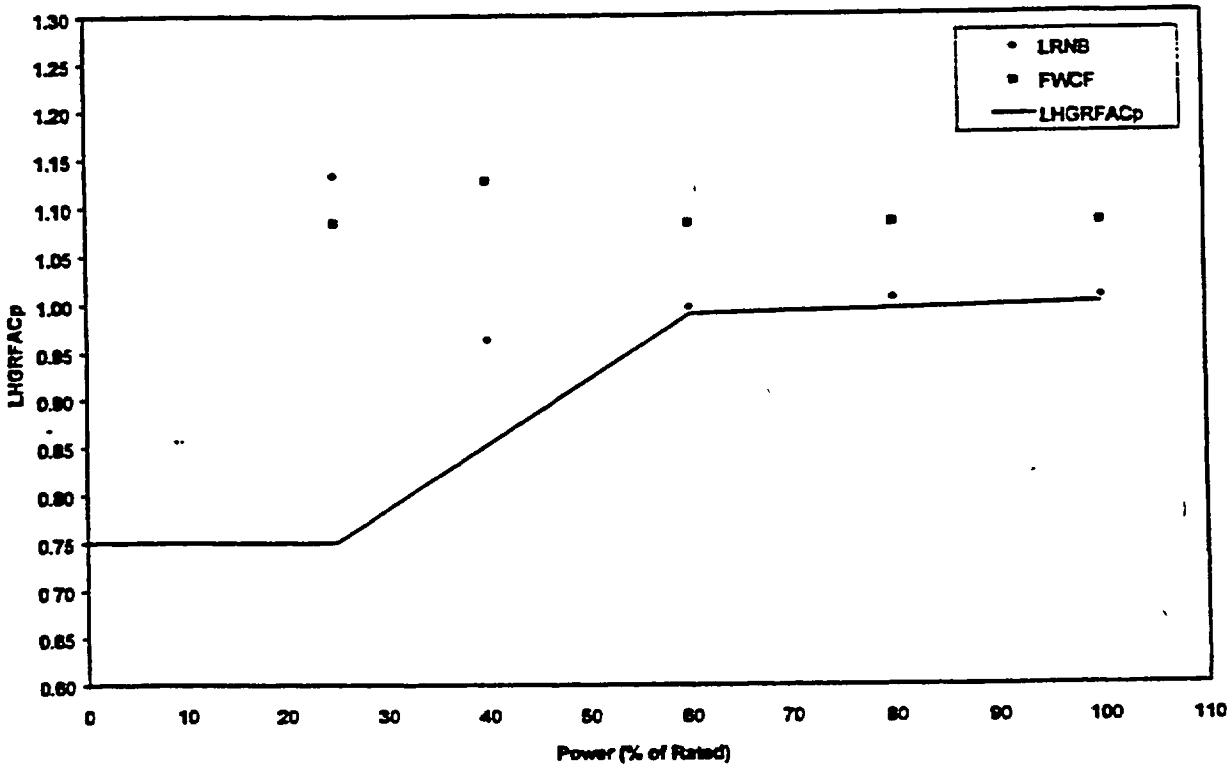
Table 4.2 FFTR/Coastdown Operation Transient Results

Event	Power/ Flow (% rated / % rated)	ATRIUM		GE9
		ΔCPR	$LHGRFAC_p$	ΔCPR
LRNB	100 / 105	0.26	1.04	0.29
LRNB	80 / 105	0.25	1.04	0.30
LRNB	60 / 105	0.27	1.01	0.28
LRNB	40 / 105	0.25	0.99	0.25
LRNB	25 / 105	0.14	1.18	0.15
FWCF	100 / 105	0.26	1.09	0.28
FWCF	80 / 105	0.30	1.09	0.33
FWCF	60 / 105	0.37	1.09	0.40
FWCF	40 / 105	0.50	1.07	0.50
FWCF	25 / 105	1.10	0.95	1.12



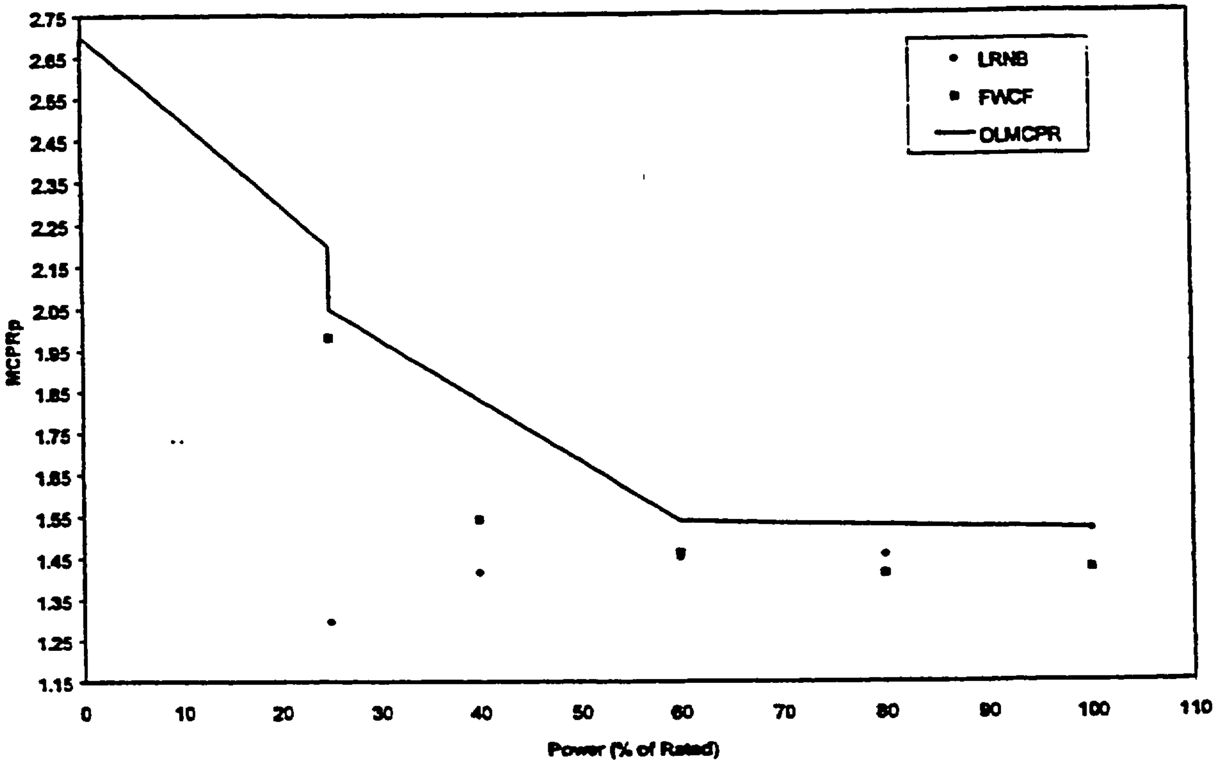
Power (%)	$MCPR_p$ Limit
100	1.42
60	1.48
25	2.05
25	2.20
0	2.70

Figure 4.1 Coastdown Power-Dependent MCPR Limits for ATRUM-9B Fuel



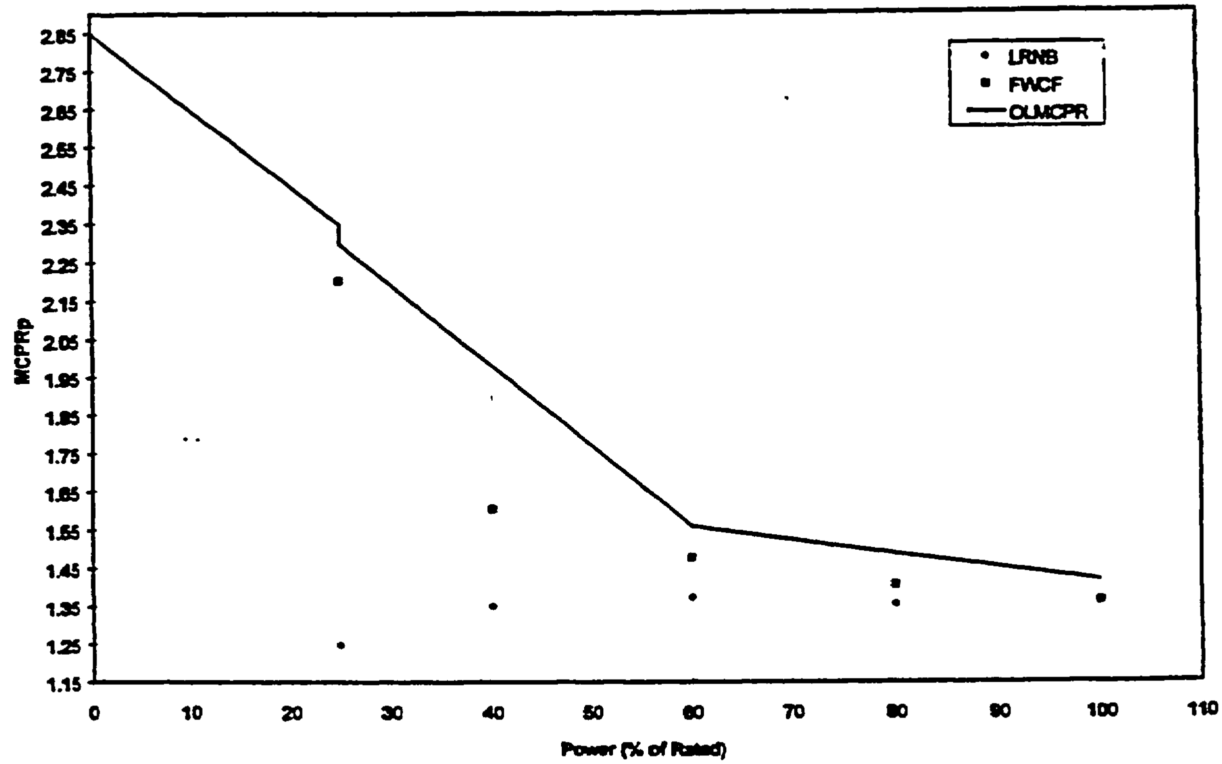
Power (%)	$LHGRFAC_p$ Multiplier
100	1.00
60	0.99
25	0.75
25	0.75
0	0.75

Figure 4.2 Coastdown Power-Dependent LHGR Multipliers for ATRUM-9B Fuel



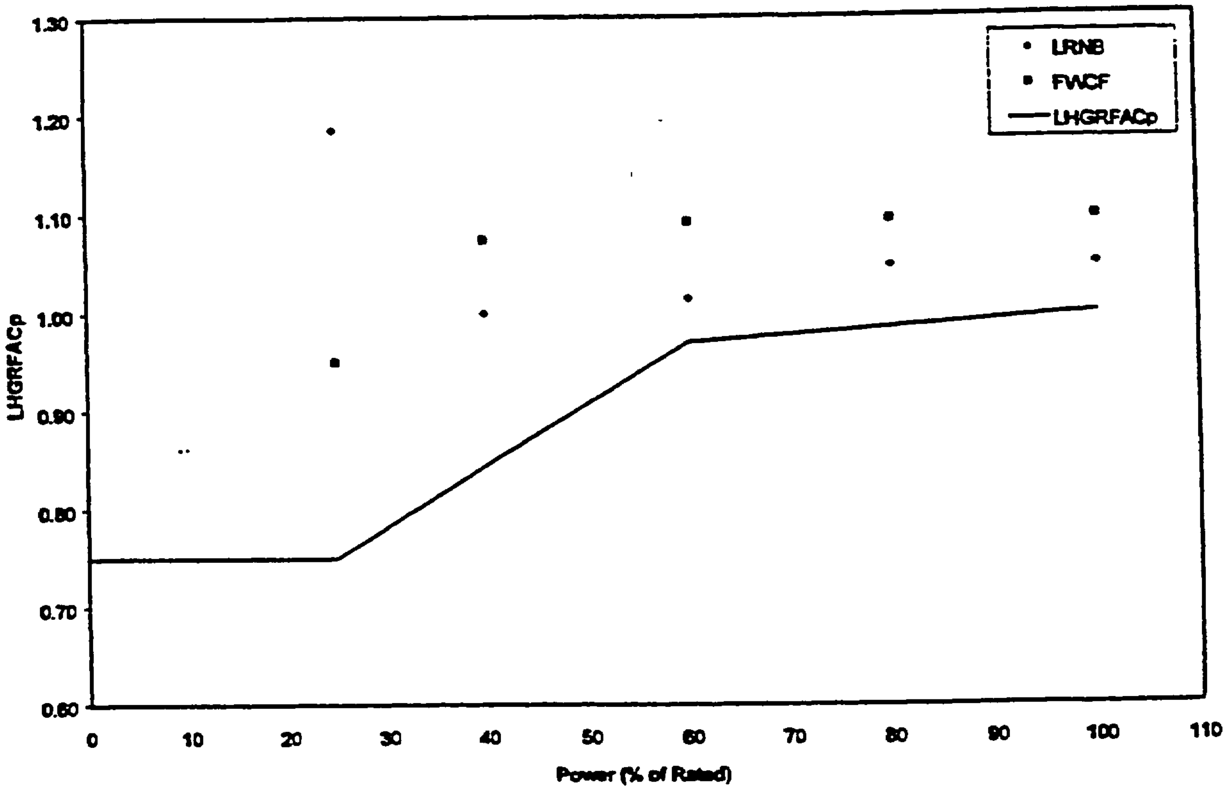
Power (%)	MCPR$_p$ Limit
100	1.52
60	1.54
25	2.05
25	2.20
0	2.70

Figure 4.3 Coastdown Power-Dependent MCPR Limits for GE9 Fuel



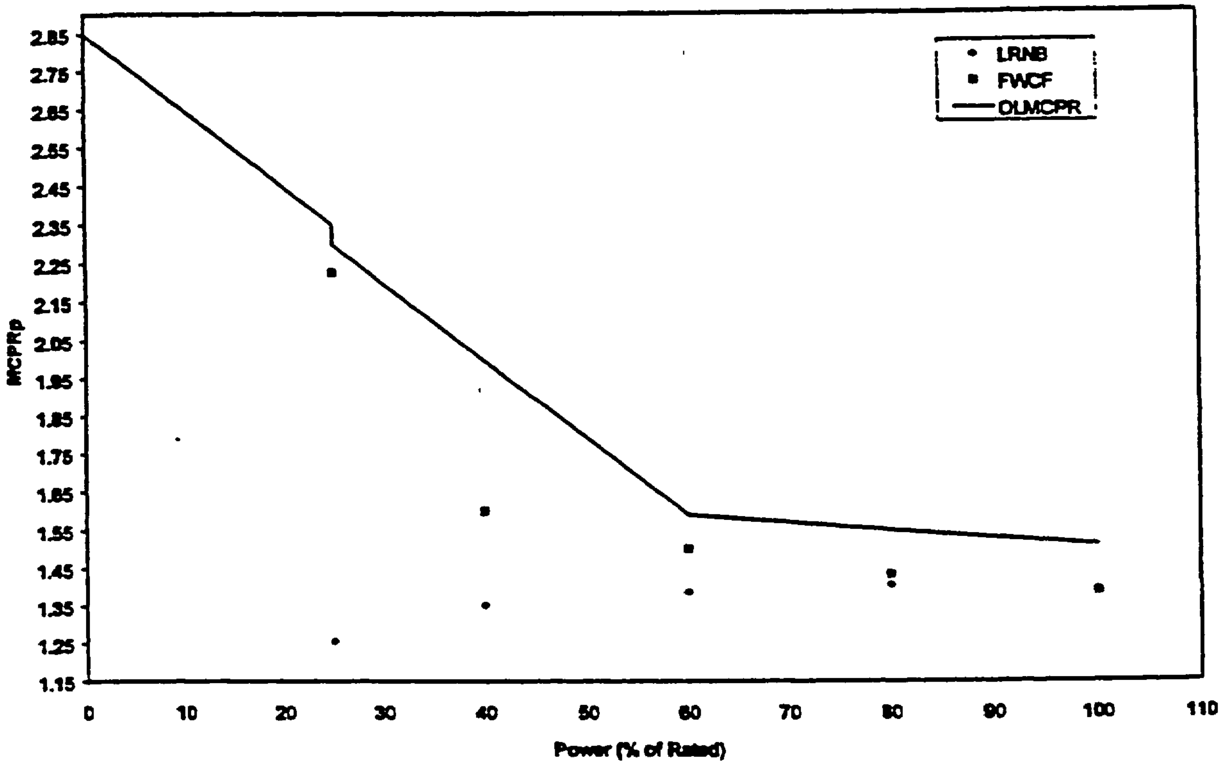
Power (%)	$MCPR_p$ Limit
100	1.42
60	1.56
25	2.30
25	2.35
0	2.85

Figure 4.4 FFTR/Coastdown Power-Dependent MCPR Limits for ATRUM-9B Fuel



Power (%)	$LHGRFAC_p$ Multiplier
100	1.00
60	0.97
25	0.65
25	0.65
0	0.65

Figure 4.5 FFTR/Coastdown Base Case Power-Dependent LHGR Multipliers for ATRUM-9B Fuel



Power (%)	$MCPR_p$ Limit
100	1.52
60	1.59
25	2.30
25	2.35
0	2.85

Figure 4.6 FFTR/Coastdown Power-Dependent MCPR Limits for GE9 Fuel

5.0 Transient Analysis for Thermal Margin - Equipment Out-of-Service

This section describes the development of the MCPR and LHGR operating limits to support operation with the following EOOS scenarios:

- Feedwater heaters out-of-service (FHOOS) – 100°F feedwater temperature reduction.
- 1 recirculation pump loop (SLO).
- Turbine bypass system out-of-service (TBVOOS).
- Recirculation pump trip out-of-service (No RPT).
- Slow closure of 1 or more turbine control valves.

Operation with 1 SRV out-of-service, up to 2 TIPOOS (or the equivalent number of TIP channels) and up to 50% of the LPRMs out-of-service is supported by the base case thermal limits presented in Section 3.0. No further discussion for these EOOS scenarios is presented in this section. The EOOS analyses presented in this section also include the same EOOS scenarios protected by the base case limits.

Results of the limiting transient analyses are used to establish appropriate $MCPR_p$ limits and $LHGRFAC_p$ multipliers to support operation in the EOOS scenarios. All EOOS analyses were performed with TSSS insertion times.

As discussed in Reference 9, the base case MCPR safety limit for two-loop operation remains applicable for operation in the EOOS scenarios discussed below with the exception of single-loop operation. Also, the flow-dependent MCPR and LHGR analyses described in Section 3.4 were performed such that the results are applicable in all the EOOS scenarios.

5.1 *Feedwater Heaters Out-of-Service (FHOOS)*

The FHOOS scenario assumes a 100°F reduction in the feedwater temperature. Operation with FHOOS is similar to operation with FFTR except that the reduction in feedwater temperature due to FHOOS can occur at any time during the cycle. The effect of the reduced feedwater temperature is an increase in the core subcooling which can change the power shape and core void fraction. While the LRNB event is less severe due to the decrease in steam flow, the FWCF event can get worse due to the increase in core inlet subcooling. FWCF analyses were performed for Cycle 9 to determine thermal limits to support operation with FHOOS. The ΔCPR and $LHGRFAC_p$ results used to develop the EOC operating limits with FHOOS are presented in Table 5.1. The EOC $MCPR_p$ limits and $LHGRFAC_p$ multipliers for ATRIUM-9B fuel for FHOOS operation are presented in Figures 5.1 and 5.2, and the EOC FHOOS GE9 $MCPR_p$ limits are presented in Figure 5.3.

5.2 *Single-Loop Operation (SLO)*

5.2.1 Base Case Operation

The impact of SLO at LaSalle on thermal limits was presented in Reference 9. The only impact is on the MCPR safety limit. As presented in Section 3.2, the single-loop operation safety limit is 0.01 greater than the two-loop operating limit (1.12 compared to 1.11). The base case ΔCPRs and $LHGRFAC_p$ multipliers remain applicable. The net result is an increase to the base case $MCPR_p$ limits of 0.01 as a result of the increase in the MCPR safety limit.

5.2.2 Idle Loop Startup

The $MCPR_p$ limits and $LHGRFAC_p$ multipliers for the startup of an idle recirculation pump are based on the results of the abnormal startup of the idle recirculation loop analysis and the SLO MCPR safety limit analysis. As discussed in Section 3.2, the single-loop operation safety limit is 1.12 or 0.01 higher than the two-loop operation limit. The process used for the abnormal startup of the idle recirculation loop analysis for L2C9 is presented in Reference 20. The responses of the system parameters for the L2C9 analysis are consistent with those presented in Reference 20. The Reference 20 results demonstrated that the lowest power (35%P/47%F) conditions provide conservative results. Subsequently, the L2C9 analyses were performed at 35%P/47%F. The limiting exposure was determined to be BOC. The ΔCPR and $LHGRFAC_p$ results for the abnormal startup of the idle recirculation loop are presented in Table 5.2. Figures 5.4 and 5.5 present the ATRIUM-9B $MCPR_p$ limits and $LHGRFAC_p$ multipliers for idle loop startup. The GE9 $MCPR_p$ limits for idle loop startup are presented in Figure 5.6.

5.3 *Turbine Bypass Valves Out-of-Service (TBVOOS)*

The effect of operation with TBVOOS is a reduction in the system pressure relief capacity, which makes the pressurization events more severe. While the base case LRNB event is analyzed assuming the turbine bypass system out-of-service, operation with TBVOOS has an effect on the FWCF event. The FWCF event was evaluated for LaSalle Unit 2 Cycle 9 to support operation with TBVOOS. The ΔCPR and $LHGRFAC_p$ results used to develop the EOC operating limits with TBVOOS are presented in Table 5.3. The EOC $MCPR_p$ limits and $LHGRFAC_p$

multipliers for ATRIUM-9B fuel for TBVOOS operation are presented in Figures 5.7 and 5.8, and the EOC TBVOOS GE9 $MCPR_p$ limits are presented in Figure 5.9.

5.4 *Recirculation Pump Trip Out-of-Service (No RPT)*

This section summarizes the development of the thermal limits to support operation with the EOC RPT inoperable. When RPT is inoperable, no credit for tripping the recirculation pump on TSV position or TCV fast closure is assumed. The function of the RPT feature is to reduce the severity of the core power excursion caused by the pressurization transient. The RPT accomplishes this by helping revoid the core, thereby reducing the magnitude of the reactivity insertion resulting from the pressurization transient. Failure of the RPT feature can result in higher operating limits because of the higher positive reactivity in the core at the time of control rod insertion.

Analyses were performed for LRNB and FWCF events assuming no RPT. The ΔCPR and $LHGRFAC_p$ results used to develop the EOC operating limits with no RPT are presented in Table 5.4. The EOC $MCPR_p$ limits and $LHGRFAC_p$ multipliers for ATRIUM-9B fuel for operation with no RPT are presented in Figures 5.10 and 5.11, and the EOC no RPT GE9 $MCPR_p$ limits are presented in Figure 5.12.

5.5 *Slow Closure of the Turbine Control Valve*

LRNB analyses were performed to evaluate the impact of a TCV slow closure. Analyses were performed closing 3 valves in the normal fast closure mode and 1 valve in 2.0 seconds. Results provided in Reference 23 demonstrate that performing the analyses with 1 TCV closing in 2.0 seconds protects operation with up to 4 TCVs closing slowly. Sensitivity analyses below 80% power have shown that the pressure relief provided by all 4 TCVs closing slowly can be sufficient to preclude the high-flux scram set point from being exceeded. Therefore, credit for high-flux scram is not taken for analyses at 80% power and below. The 80% power TCV slow closure analyses were performed both with and without high-flux scram credited. The ΔCPR and $LHGRFAC_p$ results of the analyses performed are presented in Table 5.5.

The $MCPR_p$ limits and $LHGRFAC_p$ multipliers are established with a step change at 80% power. At 80% power, the lower-bound $MCPR_p$ limits and upper-bound $LHGRFAC_p$ multipliers are based on the analyses which credit high-flux scram; the upper-bound $MCPR_p$ limits and lower-bound $LHGRFAC_p$ multipliers are based on analyses which do not credit high-flux scram. While the TCV slow closure analysis is performed without RPT on valve position, it does not necessarily bound the LRNB no RPT or FWCF no RPT events at all power levels because the slow closing TCV provides some pressure relief until it completely closes. Therefore, the $MCPR_p$ limits and $LHGRFAC_p$ multipliers for the TCV slow closure EOOS scenario are established using the limiting of the no RPT results reported in Section 5.4 and the TCV slow closure results.

The EOC $MCPR_p$ limits and $LHGRFAC_p$ multipliers for ATRIUM-9B fuel for operation with TCV slow closure are presented in Figures 5.13 and 5.14 and the EOC TCV slow closure GE9 $MCPR_p$ limits are presented in Figure 5.15. The limits presented in Figures 5.13 through 5.15 protect the scenario of all 4 TCVs closing slowly.

5.6 *Combined FHOOS/TCV Slow Closure and/or No RPT*

$MCPR_p$ limits and $LHGRFAC_p$ multipliers were established to support operation with FHOOS, TCV slow closure and/or no RPT. The TCV slow closure ΔCPR and $LHGRFAC_p$ results with FHOOS become less limiting than the TCV slow closure event with nominal feedwater temperature since the initial steam flow with FHOOS is lower and produces a less severe pressurization event. Subsequently, no TCV slow closure with FHOOS analyses were performed. The TCV slow closure results with nominal feedwater temperature are considered in determining the combined FHOOS/TCV slow closure and/or no RPT $MCPR_p$ limits and $LHGRFAC_p$ multipliers. The limits were developed based on the limiting of either the TCV slow closure analysis results discussed in Section 5.5 or the analyses with both FHOOS and no RPT presented in Table 5.6.

The EOC $MCPR_p$ limits and $LHGRFAC_p$ multipliers for ATRIUM-9B fuel with FHOOS/TCV slow closure and/or no RPT are presented in Figures 5.16 and 5.17, and the EOC GE9 $MCPR_p$ limits for the same EOOS scenario are presented in Figure 5.18. The limits presented in Figures 5.16 through 5.18 protect the scenario of all 4 TCVs closing slowly.

Table 5.1 EOC Feedwater Heater Out-of-Service Analysis Results

Event	Power/ Flow (% rated / % rated)	ATRIUM		GE9
		ΔCPR	LHGRFAC$_p$	ΔCPR
FWCF	100 / 105	0.26	1.08*	0.31
FWCF	100 / 81	0.23	1.11	0.28
FWCF	80 / 105	0.30	1.03*	0.36
FWCF	60 / 105	0.40*	0.97*	0.46*
FWCF	40 / 105	0.62*	0.87*	0.69*
FWCF	25 / 105	1.03*	0.69*	1.11*

---

* The analysis results presented are from an earlier cycle exposure. The ΔCPR and LHGRFAC$_p$ results are conservatively used to establish the thermal limits.

Table 5.2 Abnormal Recirculation Loop Startup Analysis Results

Power / Flow (% rated / % rated)	FCV Position	ATRIUM-9B	
		ΔCPR*	LHGRFAC$_p$
35 / 47	27% open	1.46†	0.42†

---

* ΔCPR results for ATRIUM-9B fuel are conservatively applicable for GE9 fuel.

† The analysis results presented are from an earlier cycle exposure. The ΔCPR and LHGRFAC$_p$ results are conservatively used to establish the thermal limits.

Table 5.3 EOC Turbine Bypass Valves Out-of-Service Analysis Results

Event	Power / Flow (% rated / % rated)	ATRIUM		GE9
		ΔCPR	LHGRFAC$_p$	ΔCPR
FWCF	100 / 105	0.32	1.02	0.41
FWCF	100 / 81	0.31	0.99	0.41
FWCF	80 / 105	0.35	1.00*	0.45
FWCF	80 / 57.2	0.31	1.05	0.41
FWCF	60 / 105	0.41*	0.97*	0.51
FWCF	60 / 35.1	0.18	1.14	0.25
FWCF	40 / 105	0.58*	0.90*	0.66*
FWCF	25 / 105	0.87*	0.76*	0.97*

---

* The analysis results presented are from an earlier cycle exposure. The ΔCPR and LHGRFAC$_p$ results are conservatively used to establish the thermal limits.

Table 5.4 EOC Recirculation Pump Trip Out-of-Service Analysis Results

Event	Power / Flow (% rated / % rated)	ATRIUM		GE9
		ΔCPR	$LHGRFAC_p$	ΔCPR
LRNB	100 / 105	0.40	0.89	0.50
LRNB	100 / 81	0.32	0.91	0.47
LRNB	80 / 105	0.35	0.94	0.47
LRNB	80 / 57.2	0.30	0.97	0.44
LRNB	60 / 105	0.32	0.99	0.44
FWCF	100 / 105	0.31	0.97	0.40
FWCF	100 / 81	0.26	0.99	0.35
FWCF	80 / 105	0.33	1.00*	0.43
FWCF	60 / 105	0.38	0.97*	0.48
FWCF	40 / 105	0.51*	0.91*	0.59*
FWCF	25 / 105	0.78*	0.79*	0.87*

---

* The analysis results presented are from an earlier cycle exposure. The ΔCPR and $LHGRFAC_p$ results are conservatively used to establish the thermal limits.

Table 5.5 EOC Turbine Control Valve Slow Closure Analysis Results

Event	Slow Valve Characteristics	Power / Flow (% rated / % rated)	ATRIUM-9B		GE9
			ΔCPR	$LHGRFAC_p$	ΔCPR
LRNB	1 TCV closing at 2.0 sec	100 / 105[*]	0.42	0.93	0.52
LRNB	1 TCV closing at 2.0 sec	100 / 81[*]	0.33	0.97	0.49
LRNB	1 TCV closing at 2.0 sec	80 / 105[*]	0.40	0.96	0.49
LRNB	1 TCV closing at 2.0 sec	80 / 57.2[*]	0.50	0.97	0.73
LRNB	1 TCV closing at 2.0 sec	80 / 105[†]	0.52[‡]	0.86[‡]	0.62
LRNB	1 TCV closing at 2.0 sec	80 / 57.2[†]	0.58	0.92[‡]	0.84
LRNB	1 TCV closing at 2.0 sec	60 / 105[†]	0.61[‡]	0.83[‡]	0.71[‡]
LRNB	1 TCV closing at 2.0 sec	60 / 35.1[†]	0.63[‡]	0.94[‡]	0.86
LRNB	1 TCV closing at 2.0 sec	40 / 105[†]	0.78	0.77[‡]	0.84
LRNB	1 TCV closing at 2.0 sec	25 / 105[†]	0.99	0.70[‡]	0.97[‡]

---

[*] Scram initiated by high-neutron flux.

[†] Scram initiated by high dome pressure

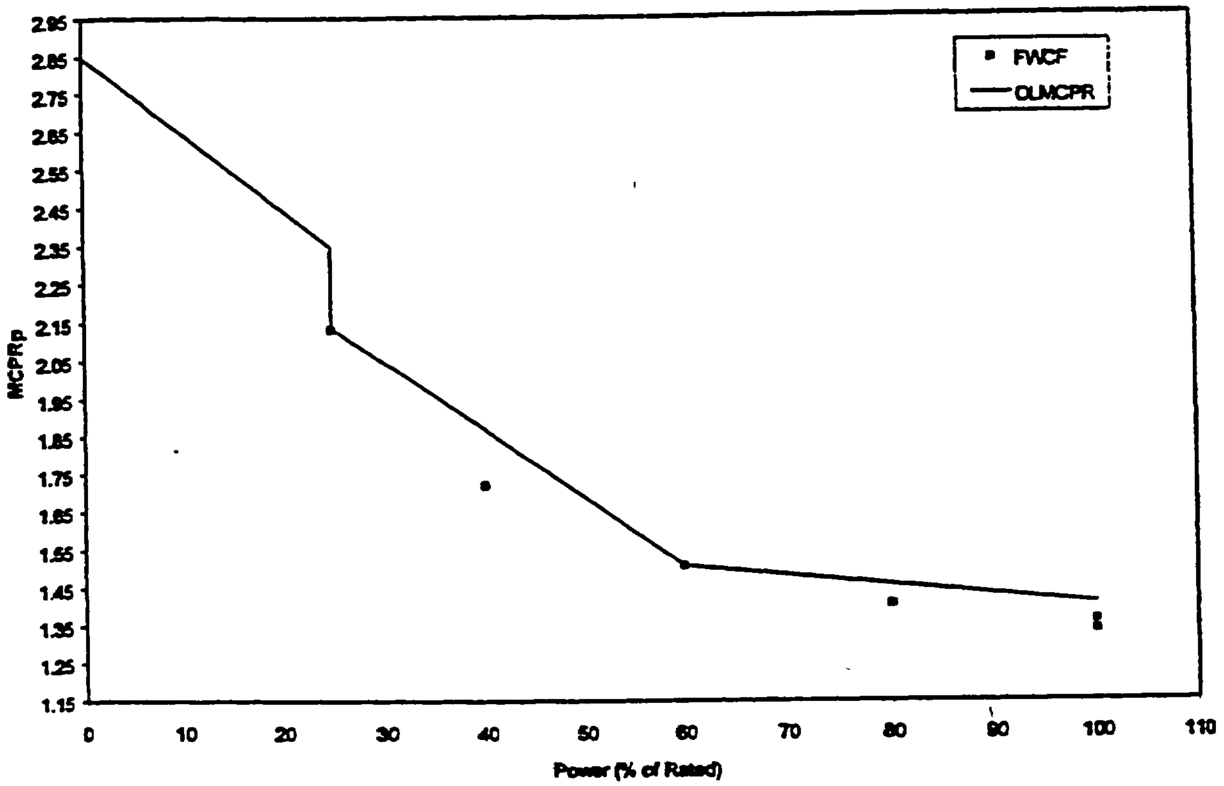
[‡] The analysis results presented are from an earlier cycle exposure. The ΔCPR and $LHGRFAC_p$ results are conservatively used to establish the thermal limits.

Table 5.6 EOC Recirculation Pump Trip and Feedwater Heater Out-of-Service Analysis Results

Event	Power / Flow (% rated / % rated)	ATRIUM-9B		GE9
		ΔCPR	$LHGRFAC_p$	ΔCPR
FWCF	100 / 105	0.30	0.98	0.39
FWCF	100 / 81	0.25	1.03	0.33
FWCF	80 / 105	0.35	0.98*	0.43
FWCF	60 / 105	0.42	0.94*	0.51
FWCF	40 / 105	0.61*	0.85*	0.70*
FWCF	25 / 105	1.01*	0.68*	1.09*

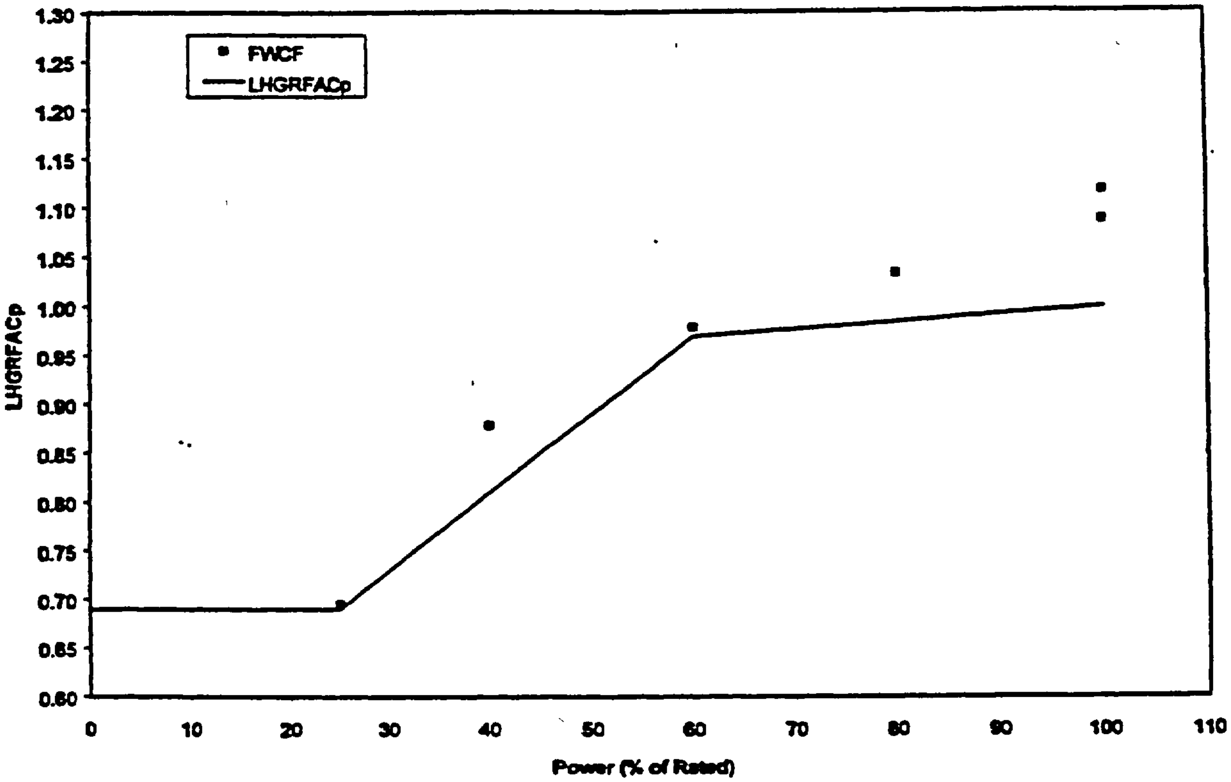
---

* The analysis results presented are from an earlier cycle exposure. The ΔCPR and $LHGRFAC_p$ results are conservatively used to establish the thermal limits.



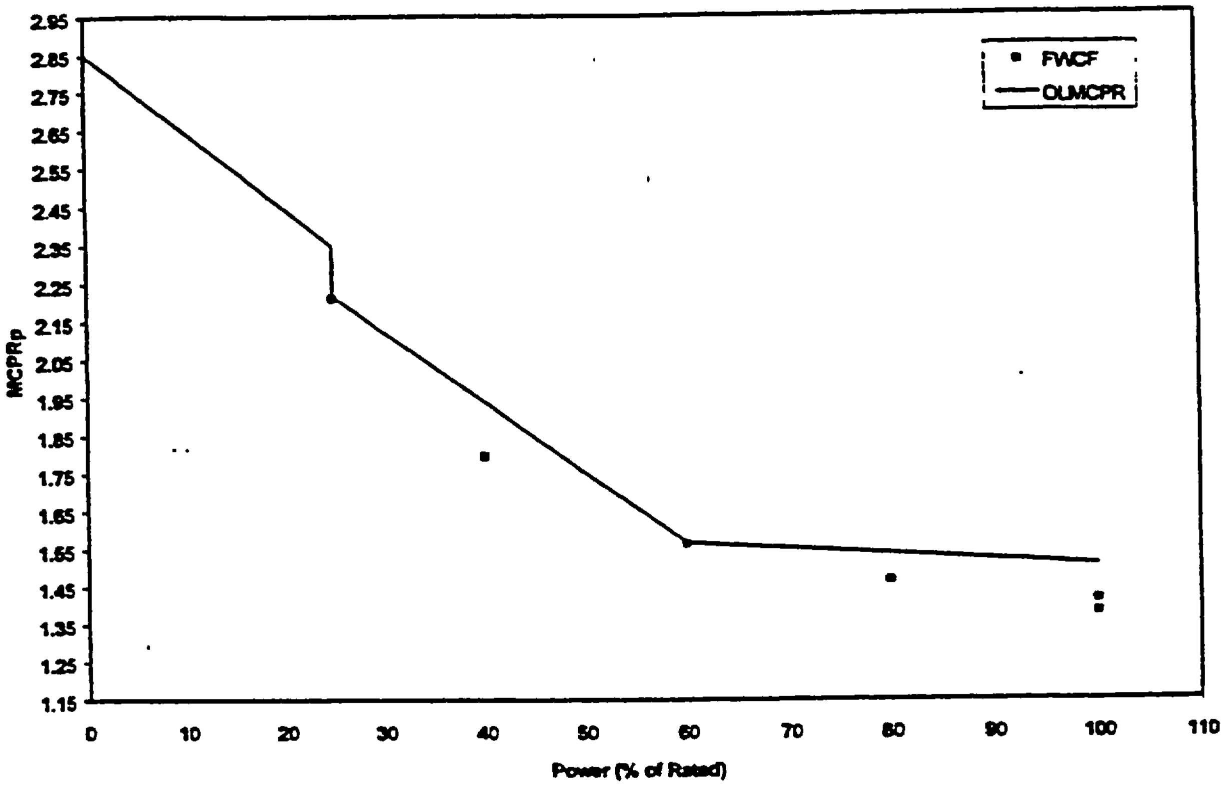
Power (%)	$MCPR_p$ Limit
100	1.41
60	1.51
25	2.14
25	2.35
0	2.85

Figure 5.1 EOC Feedwater Heaters Out-of-Service Power-Dependent MCPR Limits for ATRIUM-9B Fuel



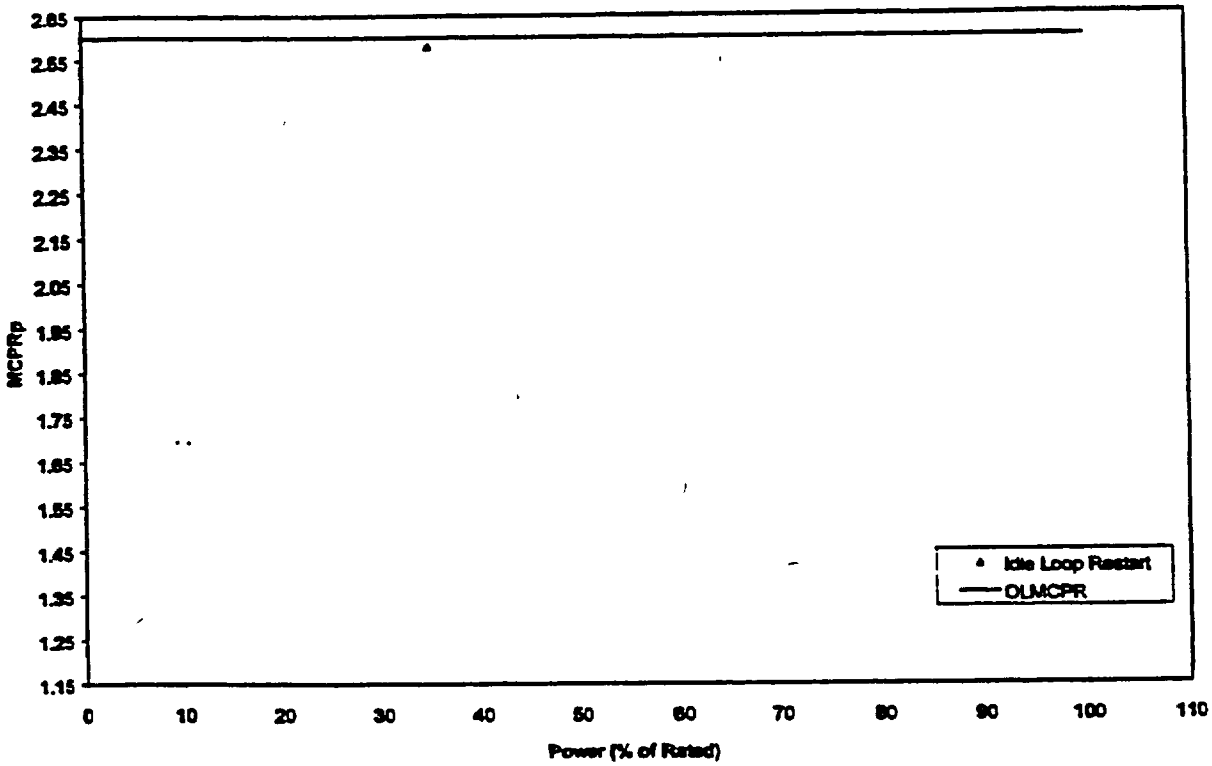
Power (%)	$LHGRFAC_p$ Multiplier
100	1.00
60	0.97
25	0.69
25	0.69
0	0.69

Figure 5.2 EOC Feedwater Heaters Out-of-Service Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



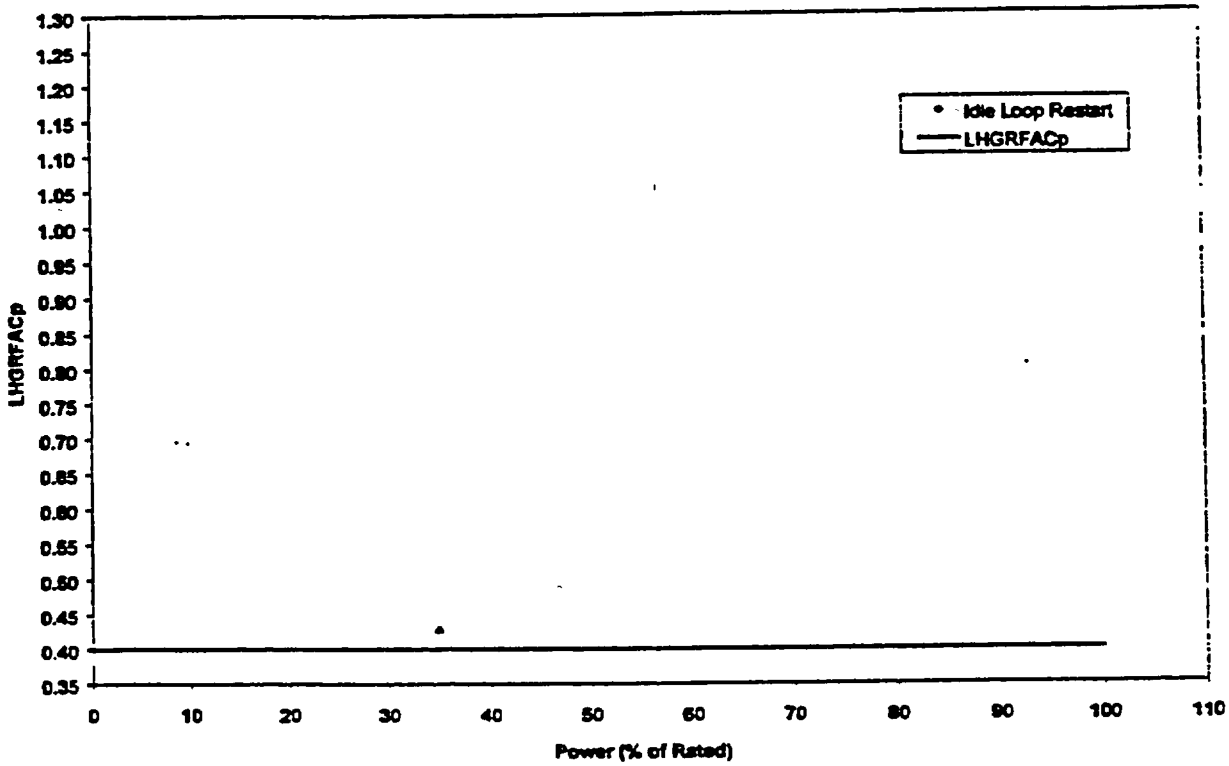
Power (%)	$MCPR_p$ Limit
100	1.51
60	1.57
25	2.22
25	2.35
0	2.85

Figure 5.3 EOC Feedwater Heaters Out-of-Service Power-Dependent MCPR Limits for GE9 Fuel



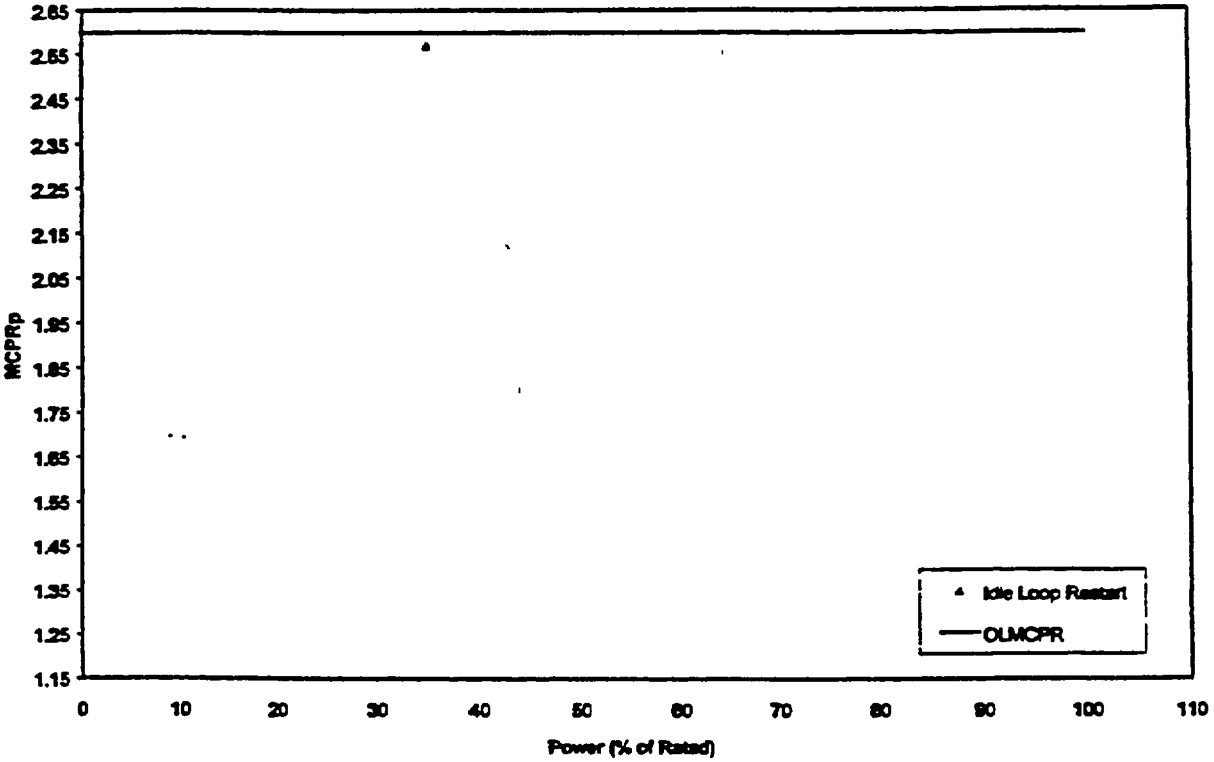
Power (%)	$MCPR_p$ Limit
100	2.60
60	2.60
25	2.60
25	2.60
0	2.60

Figure 5.4 Abnormal Idle Recirculation Loop Startup Power-Dependent MCPR Limits for ATRIUM-9B Fuel



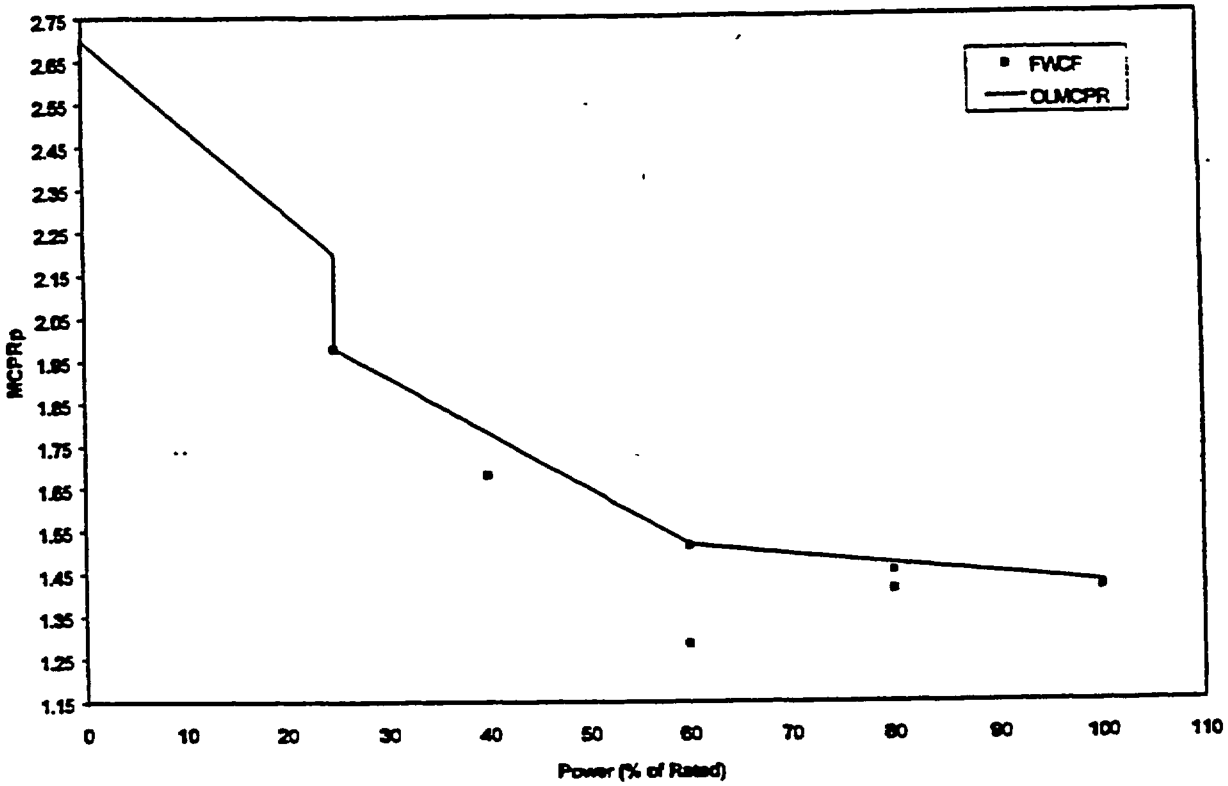
Power (%)	$LHGRFAC_p$ Multiplier
100	0.40
60	0.40
25	0.40
25	0.40
0	0.40

Figure 5.5 Abnormal Idle Recirculation Loop Startup Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



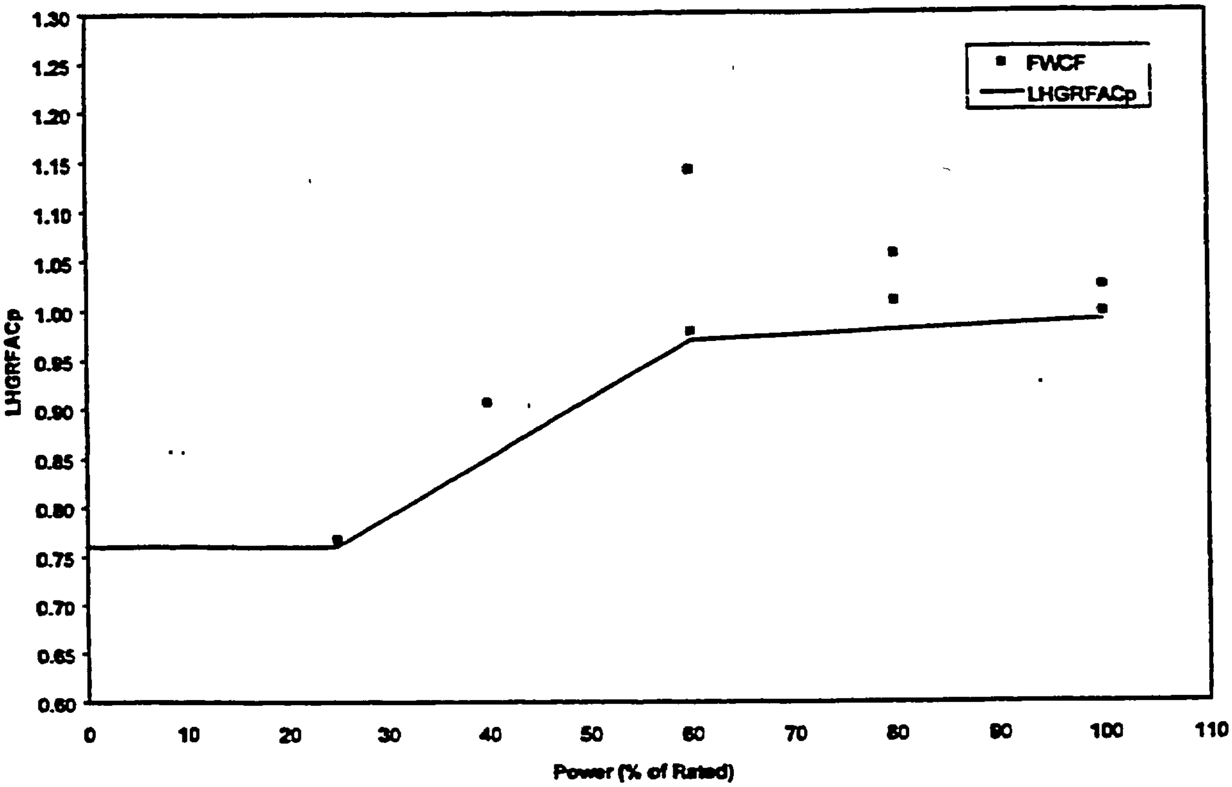
Power (%)	$MCPR_p$ Limit
100	2.60
60	2.60
25	2.60
25	2.60
0	2.60

Figure 5.6 Abnormal Idle Recirculation Loop Startup Power-Dependent MCPR Limits for GE9 Fuel



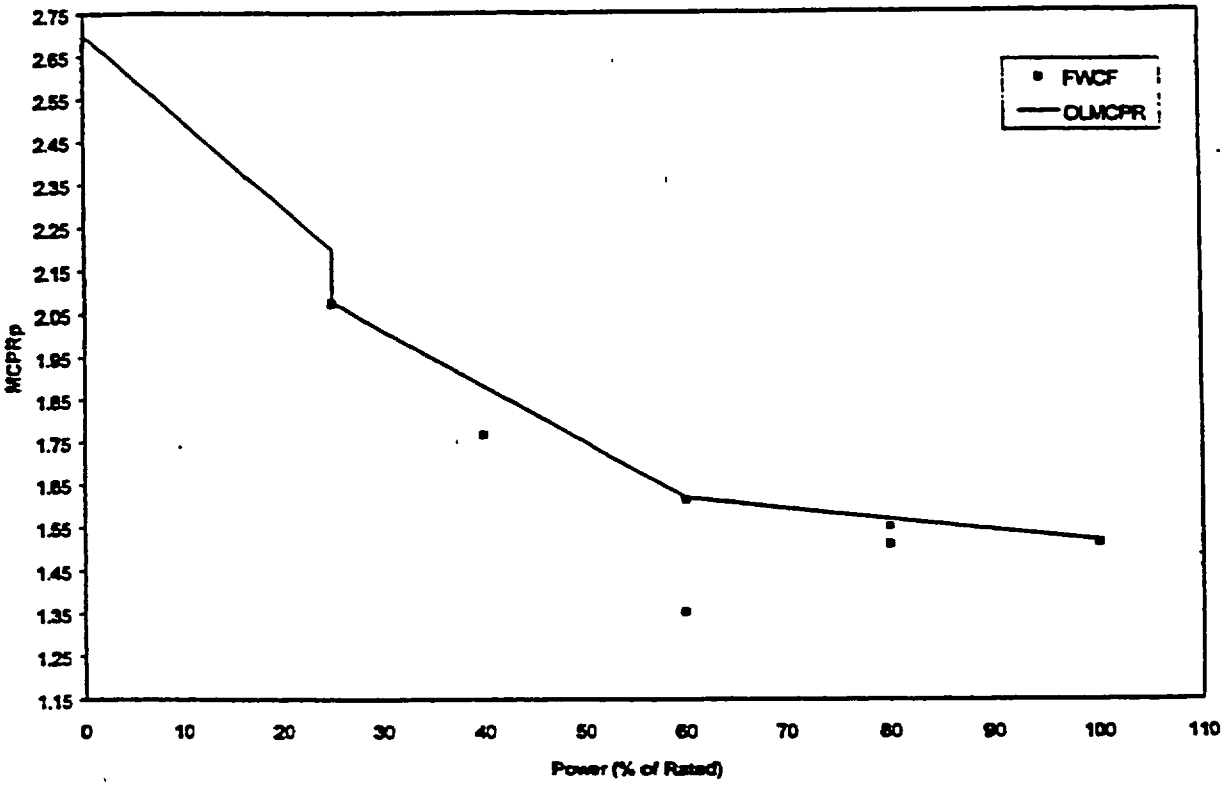
Power (%)	$MCPR_p$ Limit
100	1.43
60	1.52
25	1.98
25	2.20
0	2.70

Figure 5.7 EOC Turbine Bypass Valves Out-of-Service Power-Dependent MCPR Limits for ATRIUM-9B Fuel



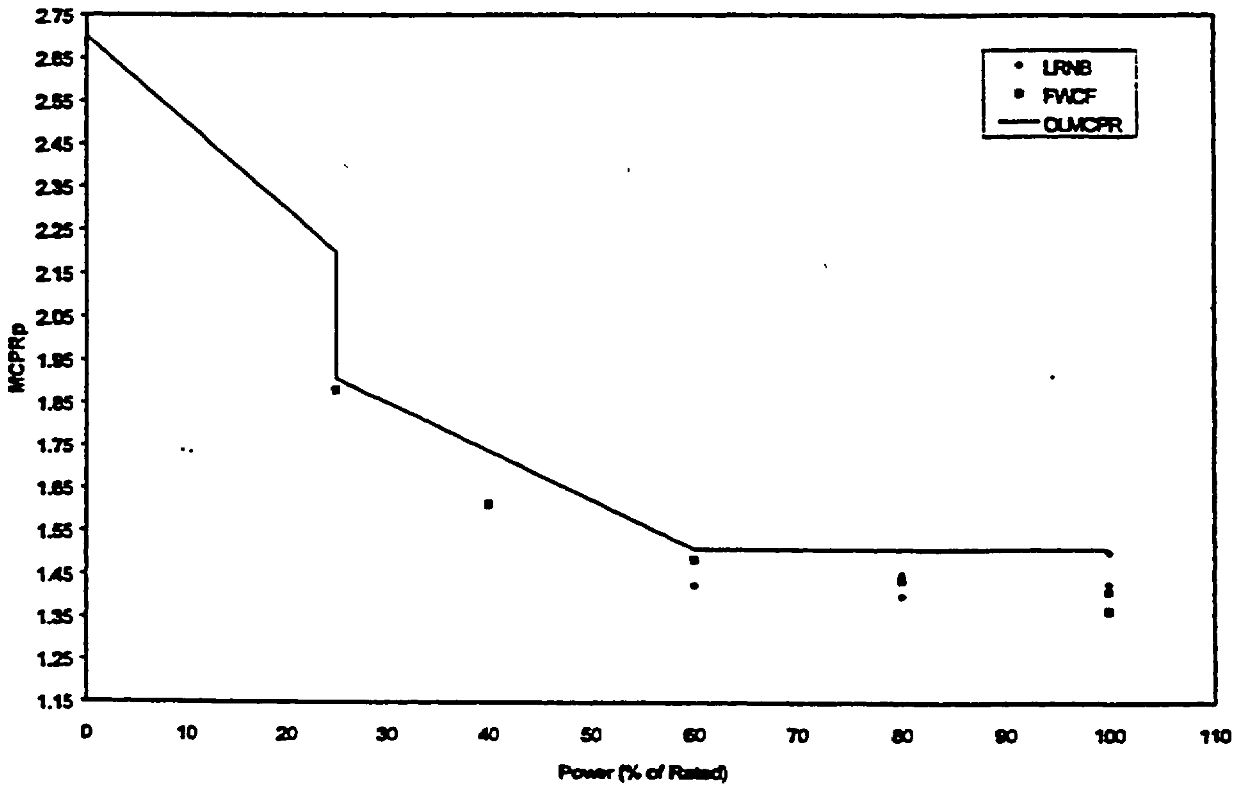
Power (%)	$LHGRFAC_p$ Multiplier
100	0.99
60	0.97
25	0.76
25	0.76
0	0.76

Figure 5.8 EOC Turbine Bypass Valves Out-of-Service Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



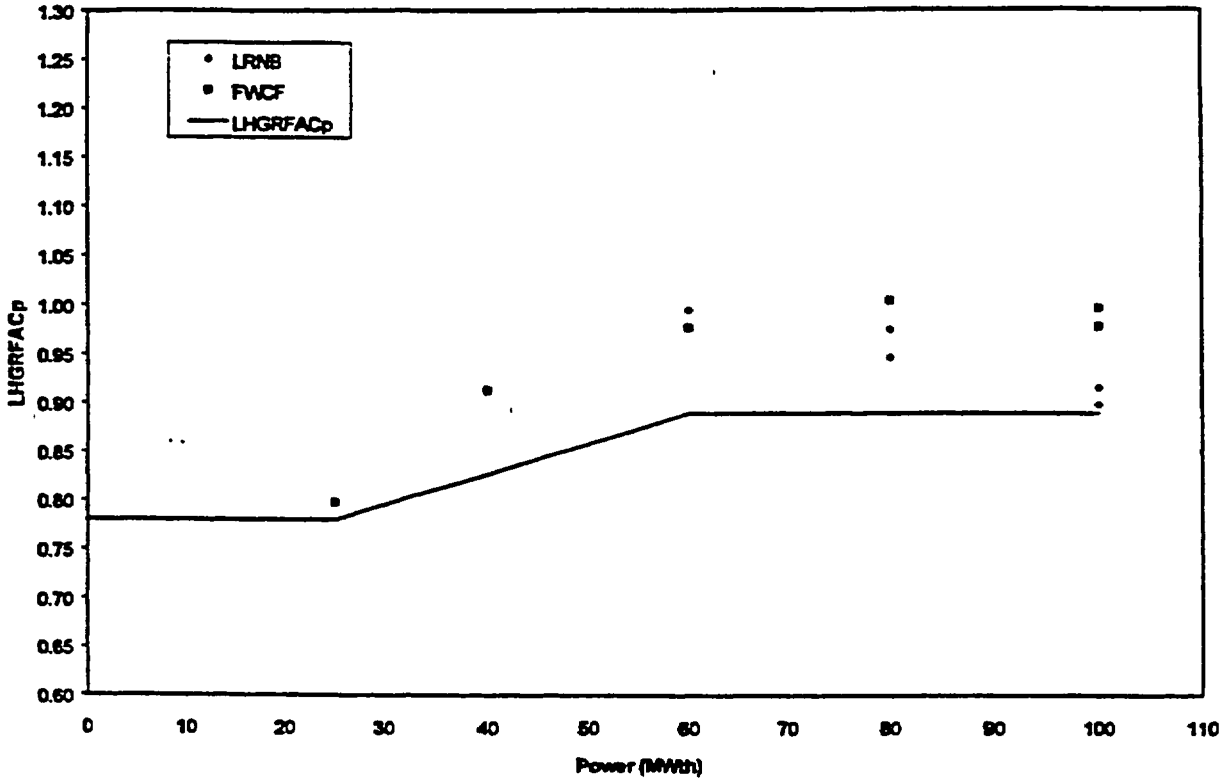
Power (%)	$MCPR_p$ Limit
100	1.52
60	1.62
25	2.08
25	2.20
0	2.70

Figure 5.9 EOC Turbine Bypass Valves Out-of-Service Power-Dependent MCPR Limits for GE9 Fuel



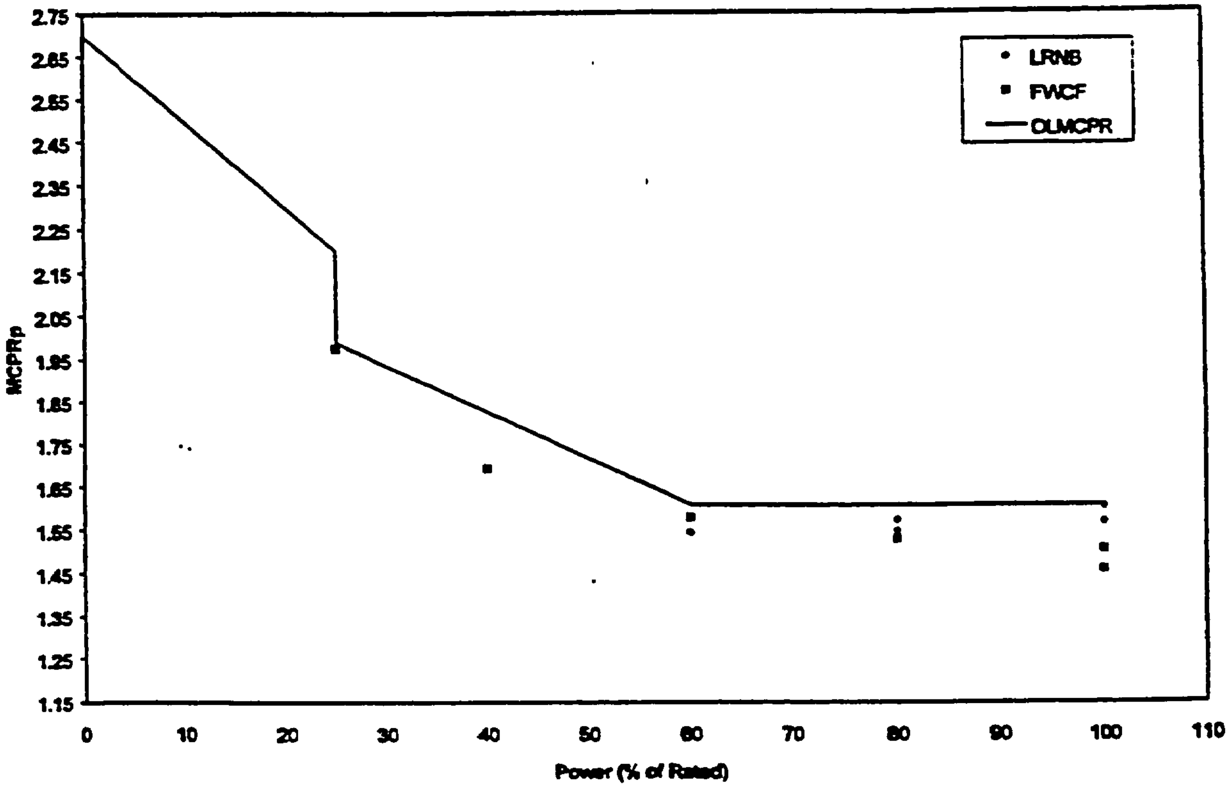
Power (%)	MCPR$_p$ Limit
100	1.51
60	1.51
25	1.91
25	2.20
0	2.70

Figure 5.10 EOC Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for ATRIUM-9B Fuel



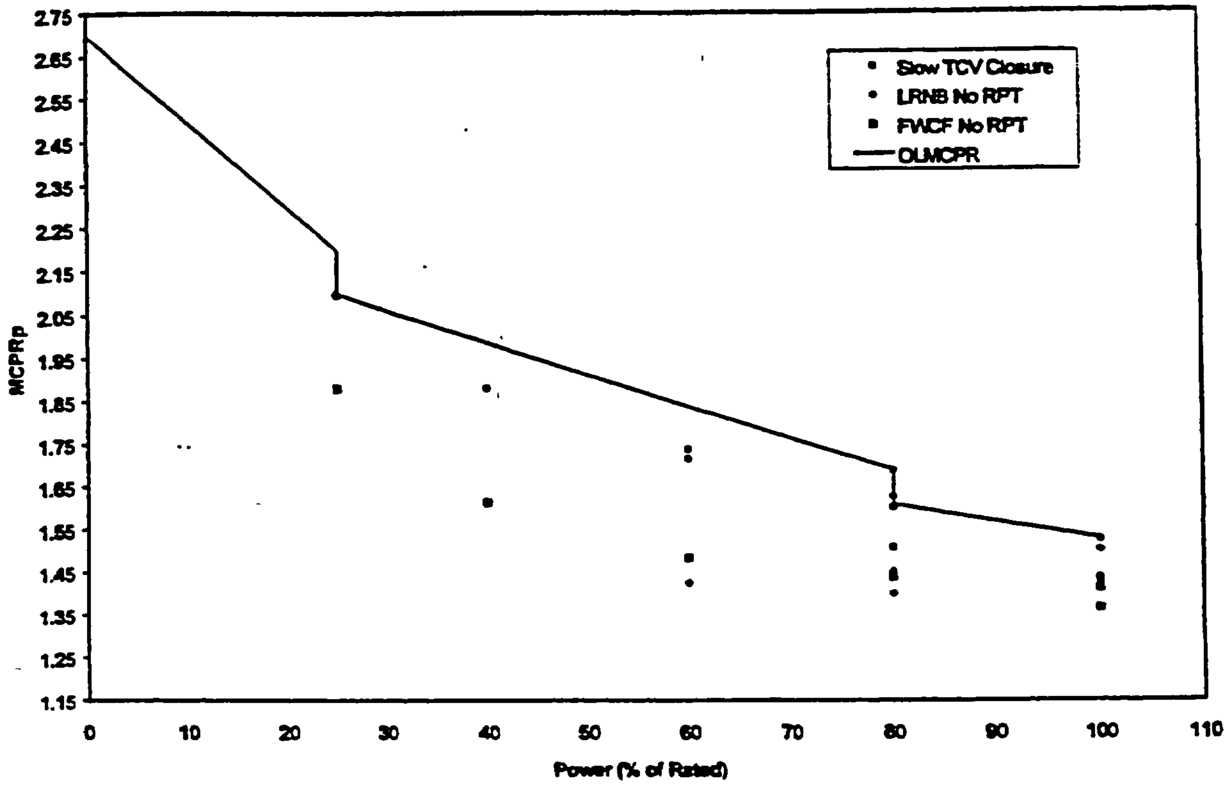
Power (%)	LHGRFAC$_p$ Multiplier
100	0.89
60	0.89
25	0.78
25	0.78
0	0.78

Figure 5.11 EOC Recirculation Pump Trip Out-of-Service Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



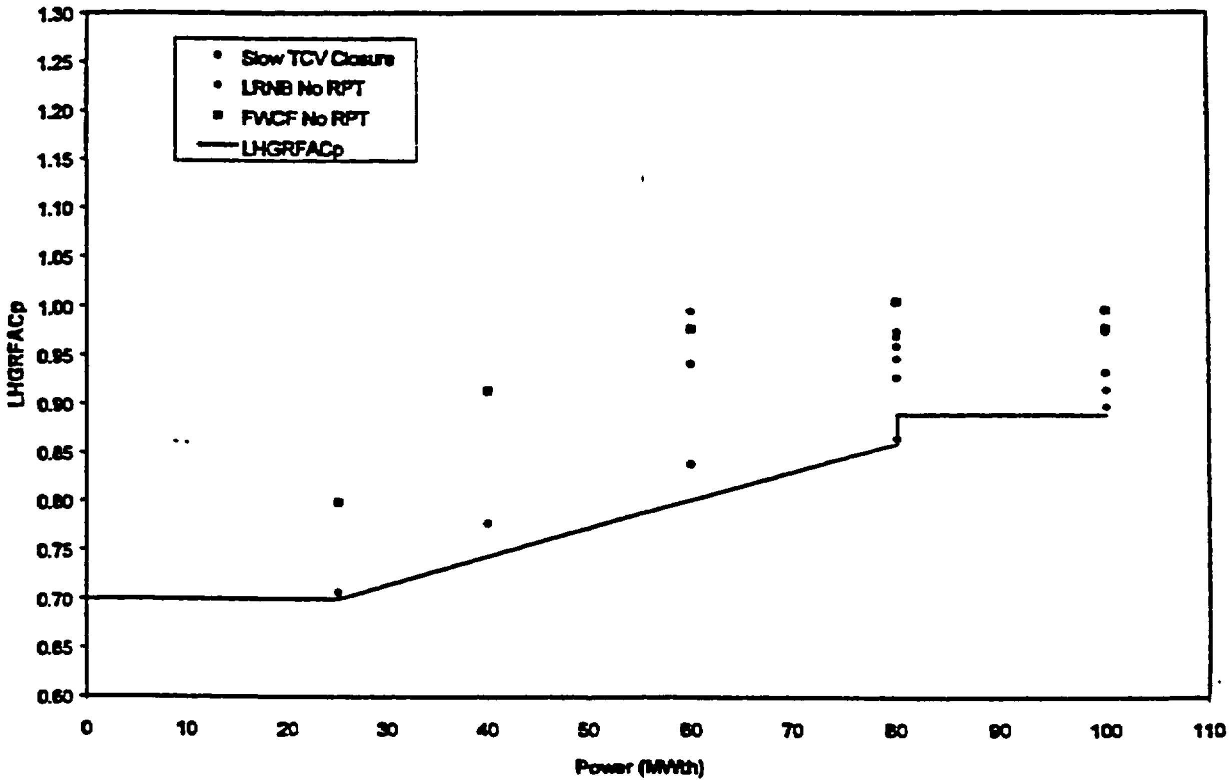
Power (%)	$MCPR_p$ Limit
100	1.61
60	1.61
25	1.99
25	2.20
0	2.70

Figure 5.12 EOC Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for GE9 Fuel



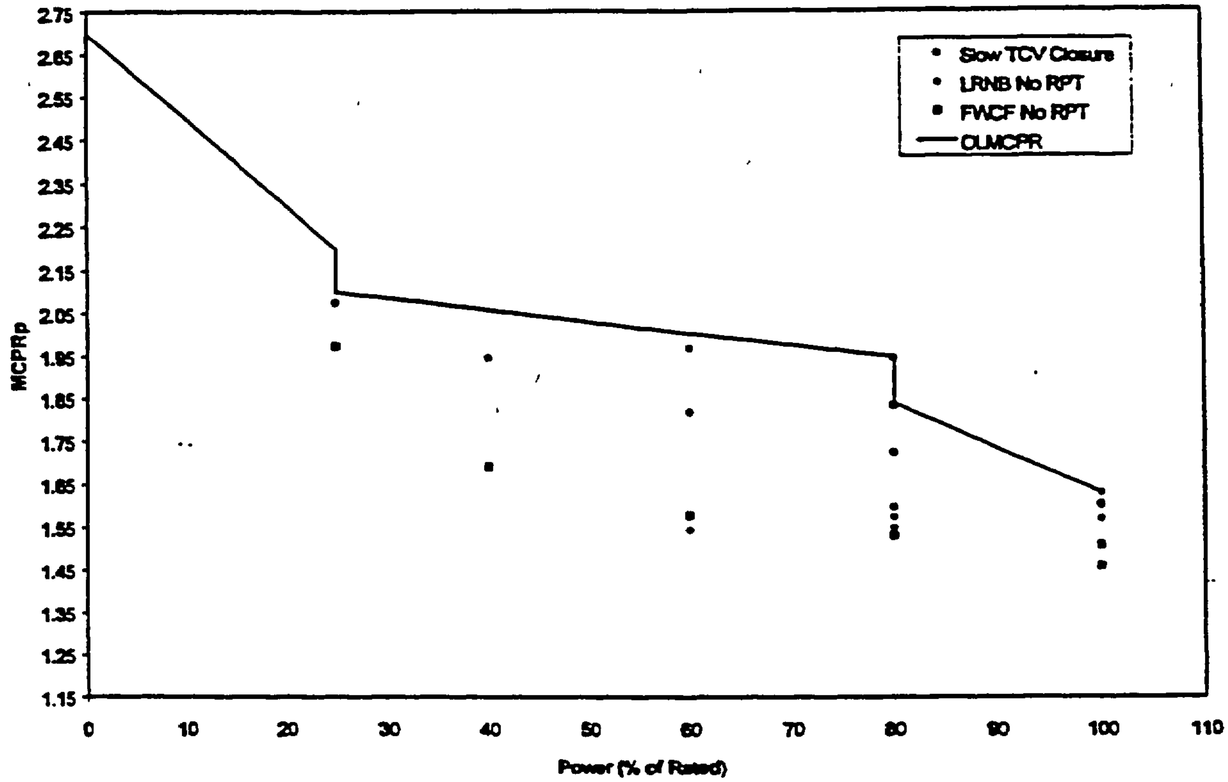
Power (%)	$MCPR_p$ Limit
100	1.53
80	1.61
80	1.69
25	2.10
25	2.20
0	2.70

Figure 5.13 EOC Turbine Control Valve Slow Closure and/or Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for ATRIUM-9B Fuel



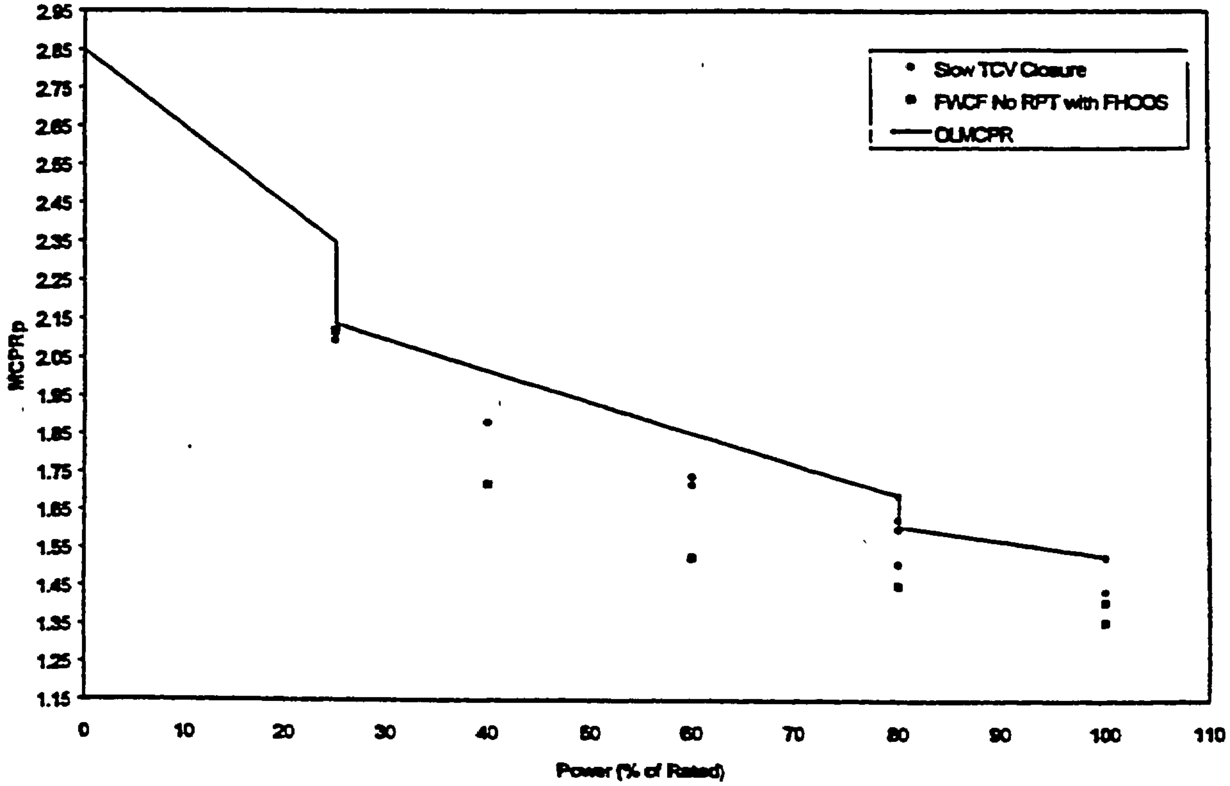
Power (%)	$LHGRFAC_p$ Multiplier
100	0.89
80	0.89
80	0.86
25	0.70
25	0.70
0	0.70

Figure 5.14 EOC Turbine Control Valve Slow Closure and/or Recirculation Pump Trip Out-of-Service Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



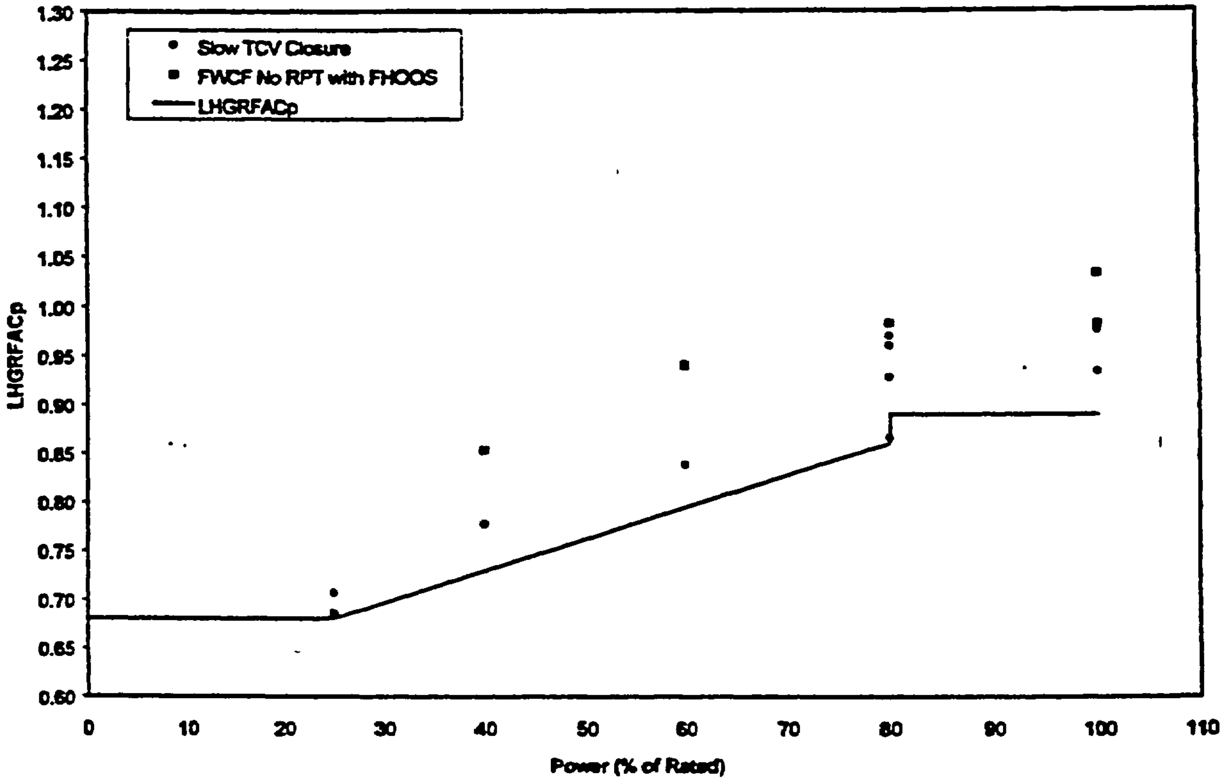
Power (%)	$MCPR_p$ Limit
100	1.63
80	1.84
80	1.95
25	2.10
25	2.20
0	2.70

Figure 5.15 EOC Turbine Control Valve Slow Closure and/or Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for GE9 Fuel



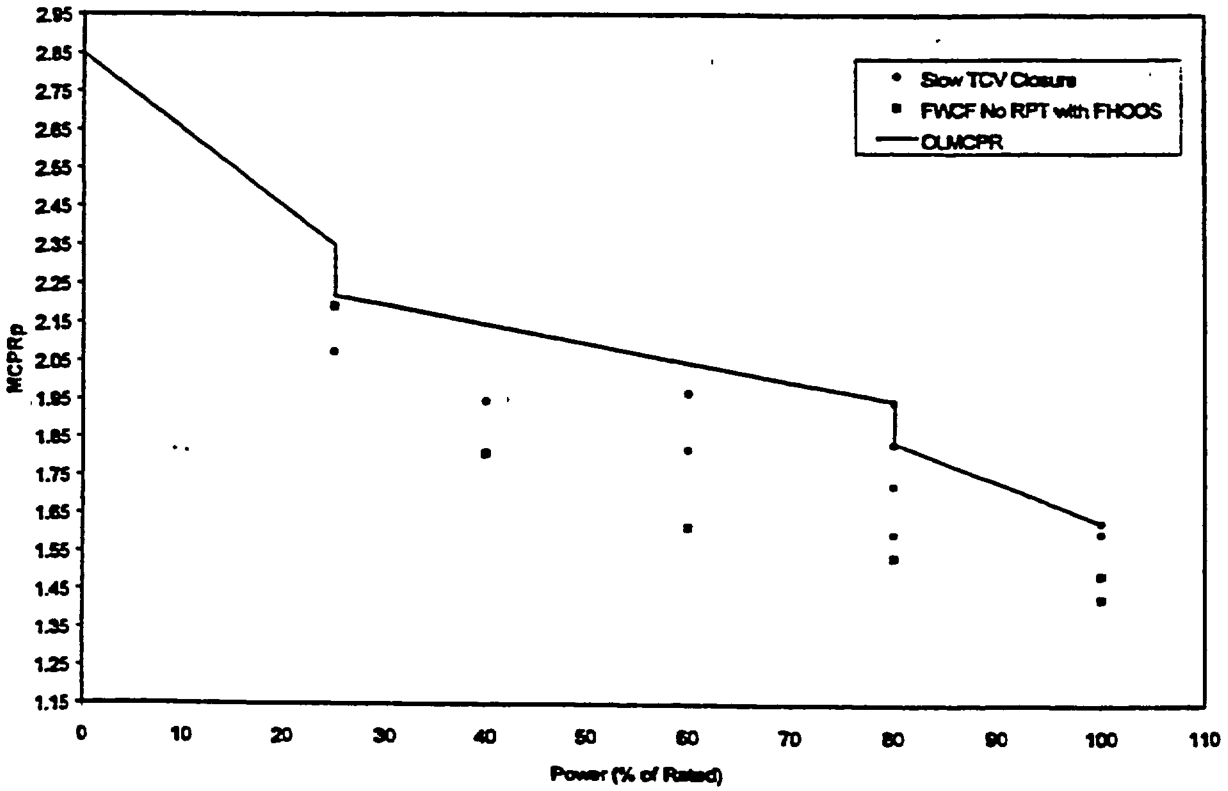
Power (%)	$MCPR_p$ Limit
100	1.53
80	1.61
80	1.69
25	2.14
25	2.35
0	2.85

Figure 5.16 EOC Turbine Control Valve Slow Closure and/or Recirculation Pump Trip and Feedwater Heaters Out-of-Service Power-Dependent MCPR Limits for ATRIUM-9B Fuel



Power (%)	$LHGRFAC_p$ Multiplier
100	0.89
80	0.89
80	0.86
25	0.68
25	0.68
0	0.68

Figure 5.17 EOC Turbine Control Valve Slow Closure and/or Recirculation Pump Trip and Feedwater Heaters Out-of-Service Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



Power (%)	$MCPR_p$ Limit
100	1.63
80	1.84
80	1.95
25	2.22
25	2.35
0	2.85

Figure 5.18 EOC Turbine Control Valve Slow Closure and/or Recirculation Pump Trip and Feedwater Heaters Out-of-Service Power-Dependent MCPR Limits for GE9 Fuel

6.0 Transient Analysis for Thermal Margin - EOD/EOOS Combinations

This section describes the transient analyses performed to determine the MCPR and LHGR operating limits to support operation in the coastdown and combined FFTR/coastdown extended operating domains in conjunction with the following EOOS scenarios:

- Feedwater heaters out-of-service (FHOOS) – 100°F feedwater temperature reduction.
- 1 recirculation pump loop (SLO).
- Turbine bypass system out-of-service (TBVOOS).
- Recirculation pump trip out-of-service (no RPT).
- Slow closure of 1 or more turbine control valves and/or no RPT.

Each of the EOOS scenarios presented also includes the failure of 1 SRV.

Results of the limiting transient analyses are used to establish $MCPR_p$ limits and $LHGRFAC_p$ multipliers to support operation in the combined EOD/EOOS scenarios. All combined EOD/EOOS analyses were performed with TSSS insertion times.

As discussed in Reference 9, the base case MCPR safety limit for two-loop operation remains applicable for operation in the combined EOD/EOOS scenarios with the exception of single-loop operation. Also, the flow-dependent MCPR and LHGR analyses described in Section 3.4 remain applicable in all the combined EOD/EOOS scenarios.

6.1 *Coastdown With EOOS*

The impact of EOOS scenarios on coastdown operation is discussed below. The $MCPR_p$ limits and $LHGRFAC_p$ values established for nominal coastdown operation remain applicable for coastdown operation with 1 safety/relief valve out-of-service, up to 2 TIPOOS (or the equivalent number of TIP channels) and up to 50% of the LPRMs out-of-service (Reference 9).

6.1.1 Coastdown With Feedwater Heaters Out-of-Service

The discussion and results presented in Section 4.3 for combined FFTR/coastdown operation are applicable to coastdown operation with FHOOS.

6.1.2 Coastdown With One Recirculation Loop

The impact of SLO at LaSalle on thermal limits was presented in Reference 9. The only impact is on the MCPR safety limit. As presented in Section 3.2, the single-loop operation safety limit is

0.01 greater than the two-loop operating limit (1.12 compared to 1.11). The base case coastdown ΔCPRs and $LHGRFAC_p$ multipliers remain applicable. The net result is an increase to the base case coastdown $MCPR_p$ limits of 0.01 as a result of the increase in the MCPR safety limit.

6.1.3 Coastdown With TBVOOS

The exposure extension during coastdown can make the effects of the pressurization transients more severe. The TBVOOS assumption also increases the severity of pressurization events. The nominal coastdown analysis for the load rejection event is performed assuming the turbine bypass system is inoperable. Therefore, the impact of the TBVOOS on the load rejection event is included in the nominal coastdown results.

The FWCF event was evaluated to ensure appropriate $MCPR_p$ limits and $LHGRFAC_p$ values are established to support coastdown operation with TBVOOS. The results of the Cycle 9 coastdown FWCF with TBVOOS analyses for both ATRIUM-9B and GE9 fuel are presented in Table 6.1. Figures 6.1 and 6.2 show the ATRIUM-9B $MCPR_p$ limits and $LHGRFAC_p$ multipliers that support coastdown operation with TBVOOS. The coastdown with TBVOOS $MCPR_p$ limits for GE9 fuel are presented in Figure 6.3.

6.1.4 Coastdown With No RPT

To ensure that appropriate $MCPR_p$ limits and $LHGRFAC_p$ multipliers are established to support coastdown operation with no RPT, analyses were performed for LRNB and FWCF events with RPT assumed inoperable. The results of the Cycle 9 coastdown no RPT analyses for both ATRIUM-9B and GE9 fuel are presented in Table 6.2. Figures 6.4 and 6.5 show the ATRIUM-9B $MCPR_p$ limits and $LHGRFAC_p$ multipliers that support coastdown operation with no RPT. The coastdown with no RPT $MCPR_p$ limits for GE9 fuel are presented in Figure 6.6.

6.1.5 Coastdown With Slow Closure of the Turbine Control Valve

The slow closure of the turbine control valve event changes the characteristics of the LRNB event in that no direct scram or RPT occurs on valve position. The effect of the increase in exposure resulting from coastdown operation can make the event more severe. The ΔCPR and $LHGRFAC_p$ results are presented in Table 6.3. While the TCV slow closure analysis is performed without RPT on valve position, it does not necessarily bound the LRNB no RPT or FWCF no RPT events at all power levels because the slow closing TCV provides some pressure relief until it completely closes. Therefore, the $MCPR_p$ limits and $LHGRFAC_p$ multipliers for the coastdown with TCV slow closure scenario are established using the limiting of the coastdown no RPT results reported in Section 6.1.4 or the TCV slow closure results.

Figures 6.7 and 6.8 present the ATRIUM-9B coastdown with TCV slow closure and/or no RPT $MCPR_p$ limits and $LHGRFAC_p$ multipliers and Figure 6.9 presents the coastdown with TCV slow closure and/or no RPT GE9 $MCPR_p$ limits.

6.2 *Combined FFTR/Coastdown With EOOS*

The impact of EOOS scenarios on combined FFTR/coastdown operation is discussed below. The FFTR/coastdown $MCPR_p$ limits and $LHGRFAC_p$ values established for combined FFTR/coastdown operation remain applicable for FFTR/coastdown operation with 1 safety/relief valve out-of-service, up to 2 TIPOOS (or the equivalent number of TIP channels) and up to 50% of the LPRMs out-of-service (Reference 9).

6.2.1 Combined FFTR/Coastdown With One Recirculation Loop

The impact of SLO at LaSalle on thermal limits was presented in Reference 9. The only impact is on the MCPR safety limit. As presented in Section 3.2, the single-loop operation safety limit is 0.01 greater than the two-loop operating limit (1.12 compared to 1.11). The base case FFTR/coastdown ΔCPRs and $LHGRFAC_p$ multipliers remain applicable. The net result is an increase to the base case FFTR/coastdown $MCPR_p$ limits of 0.01 as a result of the increase in the MCPR safety limit.

6.2.2 Combined FFTR/Coastdown With TBVOOS

The exposure extension and decrease in core inlet enthalpy during combined FFTR/coastdown operation can make the effects of the pressurization transients more severe. The TBVOOS assumption also increases the severity of pressurization events. The nominal FFTR/coastdown analysis for the load rejection event is performed assuming the turbine bypass system is inoperable. Therefore, the impact of the TBVOOS on the load rejection event is included in the nominal FFTR/coastdown results.

The FWCF event was evaluated to ensure appropriate $MCPR_p$ limits and $LHGRFAC_p$ values are established to support combined FFTR/coastdown operation with TBVOOS. The results of the Cycle 9 FFTR/coastdown FWCF with TBVOOS analyses for both ATRIUM-9B and GE9 fuel are presented in Table 6.4. Figures 6.10 and 6.11 show the ATRIUM-9B $MCPR_p$ limits and $LHGRFAC_p$ multipliers that support combined FFTR/coastdown operation with TBVOOS. The FFTR/coastdown with TBVOOS $MCPR_p$ limits for GE9 fuel are presented in Figure 6.12.

6.2.3 Combined FFTR/Coastdown With No RPT

To ensure that appropriate $MCPR_p$ limits and $LHGRFAC_p$ multipliers are established to support FFTR/coastdown operation with no RPT, analyses were performed for LRNB and FWCF events with RPT assumed inoperable. The results of the Cycle 9 FFTR/coastdown no RPT analyses for both ATRIUM-9B and GE9 fuel are presented in Table 6.5. Figures 6.13 and 6.14 show the ATRIUM-9B $MCPR_p$ limits and $LHGRFAC_p$ multipliers that support combined FFTR/coastdown operation with no RPT. The FFTR/coastdown with no RPT $MCPR_p$ limits for GE9 fuel are presented in Figure 6.15.

6.2.4 Combined FFTR/Coastdown With Slow Closure of the Turbine Control Valve

Slow closure of the turbine control valve changes the characteristics of the LRNB event in that no direct scram or RPT occurs on valve position. While the decrease in steam flow due to the FFTR tends to lessen the severity of the event, the FFTR/coastdown exposure extension may have the opposite effect. The ΔCPR and $LHGRFAC_p$ results are presented in Table 6.6. While the TCV slow closure analysis is performed without RPT on valve position, it does not necessarily bound the LRNB no RPT or FWCF no RPT events at all power levels because the slow closing TCV provides some pressure relief until it completely closes. Therefore, the $MCPR_p$ limits and $LHGRFAC_p$ multipliers for the combined FFTR/coastdown with TCV slow closure scenario are established using the limiting of the FFTR/coastdown no RPT results reported in Section 6.2.3 or the TCV slow closure results.

Figures 6.16 and 6.17 present the ATRIUM-9B combined FFTR/coastdown with TCV slow closure and/or no RPT $MCPR_p$ limits and $LHGRFAC_p$ multipliers and Figure 6.18 presents the FFTR/coastdown with TCV slow closure and/or no RPT GE9 $MCPR_p$ limits.

Table 6.1 Coastdown Turbine Bypass Valves Out-of-Service Analysis Results

Event	Power / Flow (% rated / % rated)	ATRIUM		GE9
		ΔCPR	$LHGRFAC_p$	ΔCPR
FWCF	100 / 105	0.33	1.01	0.42
FWCF	80 / 105	0.37	1.01	0.40
FWCF	60 / 105	0.42	1.00	0.46
FWCF	40 / 105	0.54	1.00	0.55
FWCF	25 / 105	0.86	1.08	0.88

Table 6.2 Coastdown Recirculation Pump Trip Out-of-Service Analysis Results

Event	Power / Flow (% rated / % rated)	ATRIUM		GE9
		ΔCPR	$LHGRFAC_p$	ΔCPR
LRNB	100 / 105	0.44	0.89	0.56
LRNB	80 / 105	0.42	0.91	0.45
LRNB	60 / 105	0.39	0.91	0.47
LRNB	40 / 105	0.39	0.87	0.41
LRNB	25 / 105	0.29	1.01	0.28
FWCF	100 / 105	0.32	0.96	0.42
FWCF	80 / 105	0.35	0.98	0.38
FWCF	60 / 105	0.39	0.99	0.44
FWCF	40 / 105	0.47	0.97	0.48
FWCF	25 / 105	0.86	1.06	0.88

Table 6.3 Coastdown Turbine Control Valve Slow Closure Analysis Results

Event	Slow Valve Characteristics	Power / Flow (% rated / % rated)	ATRIUM-9B		GE9
			ΔCPR	$LHGRFAC_p$	ΔCPR
LRNB	1 TCV closing at 2.0 sec	100 / 105*	0.44	0.93	0.55
LRNB	1 TCV closing at 2.0 sec	80 / 105*	0.45	0.94	0.48
LRNB	1 TCV closing at 2.0 sec	80 / 105†	0.52	0.95	0.55
LRNB	1 TCV closing at 2.0 sec	60 / 105†	0.59	0.96	0.61
LRNB	1 TCV closing at 2.0 sec	40 / 105†	0.79	0.87	0.78
LRNB	1 TCV closing at 2.0 sec	25 / 105†	0.99	0.74	0.93

---

* Scram initiated by high-neutron flux.

† Scram initiated by high dome pressure

Table 6.4 FFTR/Coastdown Turbine Bypass Valves Out-of-Service Analysis Results

Event	Power / Flow (% rated / % rated)	ATRIUM		GE9
		ΔCPR	$LHGRFAC_p$	ΔCPR
FWCF	100 / 105	0.32	1.03	0.35
FWCF	80 / 105	0.36	1.03	0.40
FWCF	60 / 105	0.44	1.01	0.47
FWCF	40 / 105	0.60	1.07	0.59
FWCF	25 / 105	1.10	0.95	1.12

Table 6.5 FFTR/Coastdown Recirculation Pump Trip Out-of-Service Analysis Results

Event	Power / Flow (% rated / % rated)	ATRIUM		GE9
		ΔCPR	LHGRFAC$_p$	ΔCPR
LRNB	100 / 105	0.39	0.92	0.41
LRNB	80 / 105	0.38	0.94	0.44
LRNB	60 / 105	0.40	0.92	0.41
FWCF	100 / 105	0.32	0.97	0.34
FWCF	80 / 105	0.36	0.98	0.41
FWCF	60 / 105	0.43	0.96	0.46
FWCF	40 / 105	0.56	0.91	0.56
FWCF	25 / 105	1.10	0.95	1.12

Table 6.6 FFTR/Coastdown Turbine Control Valve Slow Closure Analysis Results

Event	Slow Valve Characteristics	Power / Flow (% rated / % rated)	ATRIUM-9B		GE9
			ΔCPR	LHGRFAC$_p$	ΔCPR
LRNB	1 TCV closing at 2.0 sec	100 / 105*	0.39	0.96	0.40
LRNB	1 TCV closing at 2.0 sec	80 / 105*	0.38	0.98	0.42
LRNB	1 TCV closing at 2.0 sec	80 / 105†	0.49	0.98	0.52
LRNB	1 TCV closing at 2.0 sec	60 / 105†	0.60	0.94	0.58
LRNB	1 TCV closing at 2.0 sec	40 / 105†	0.72	0.83	0.71
LRNB	1 TCV closing at 2.0 sec	25 / 105†	0.98	0.76	0.83

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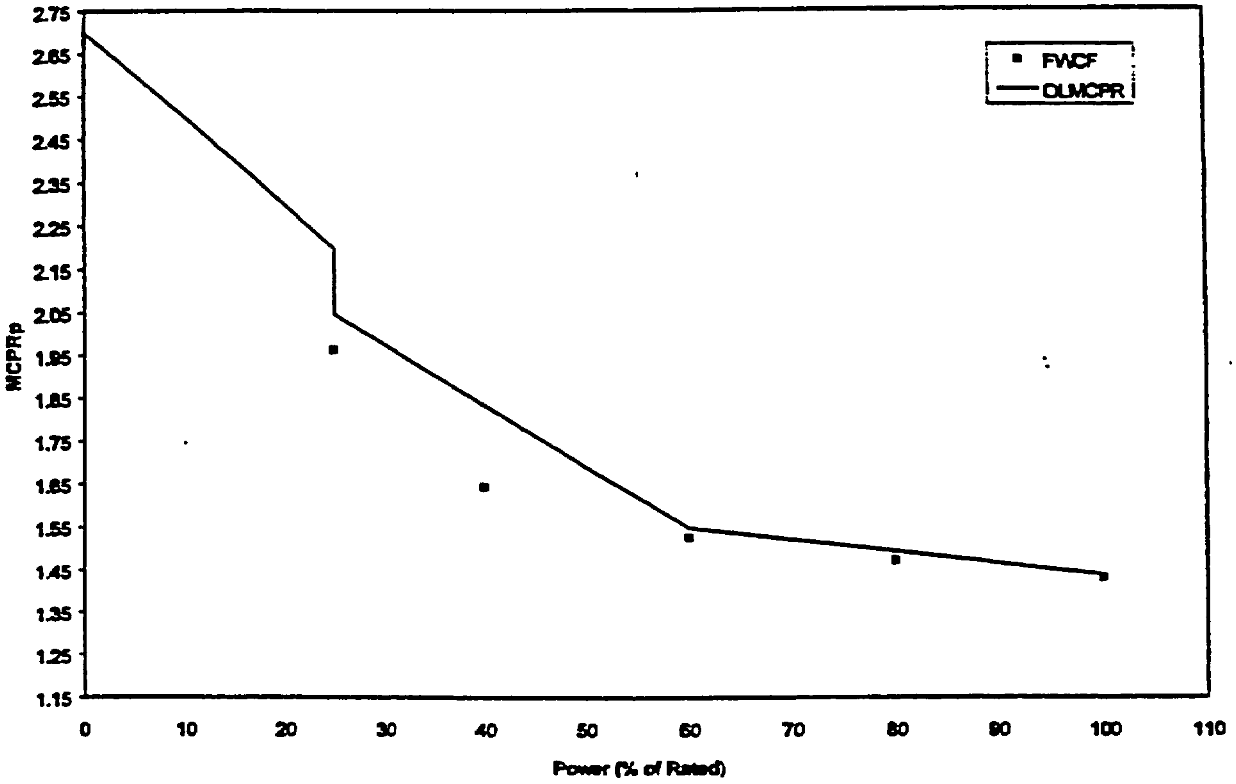
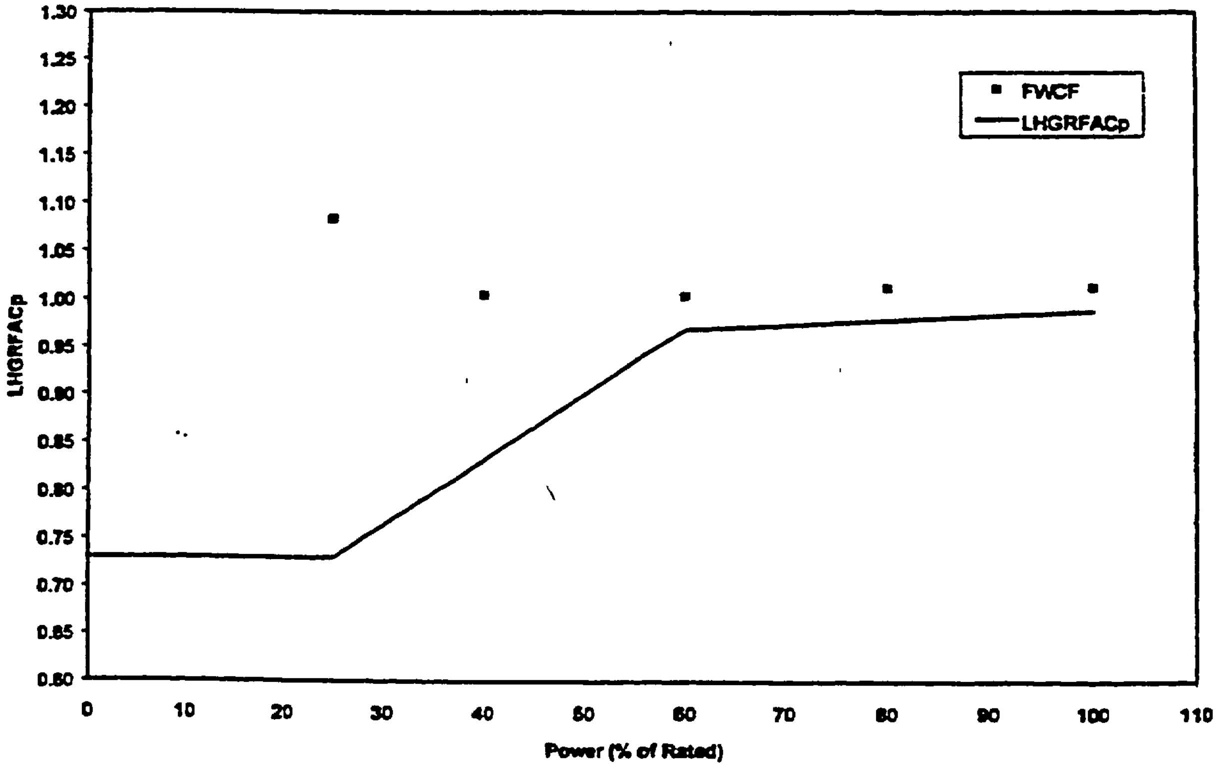
* Scram initiated by high-neutron flux.

† Scram initiated by high dome pressure



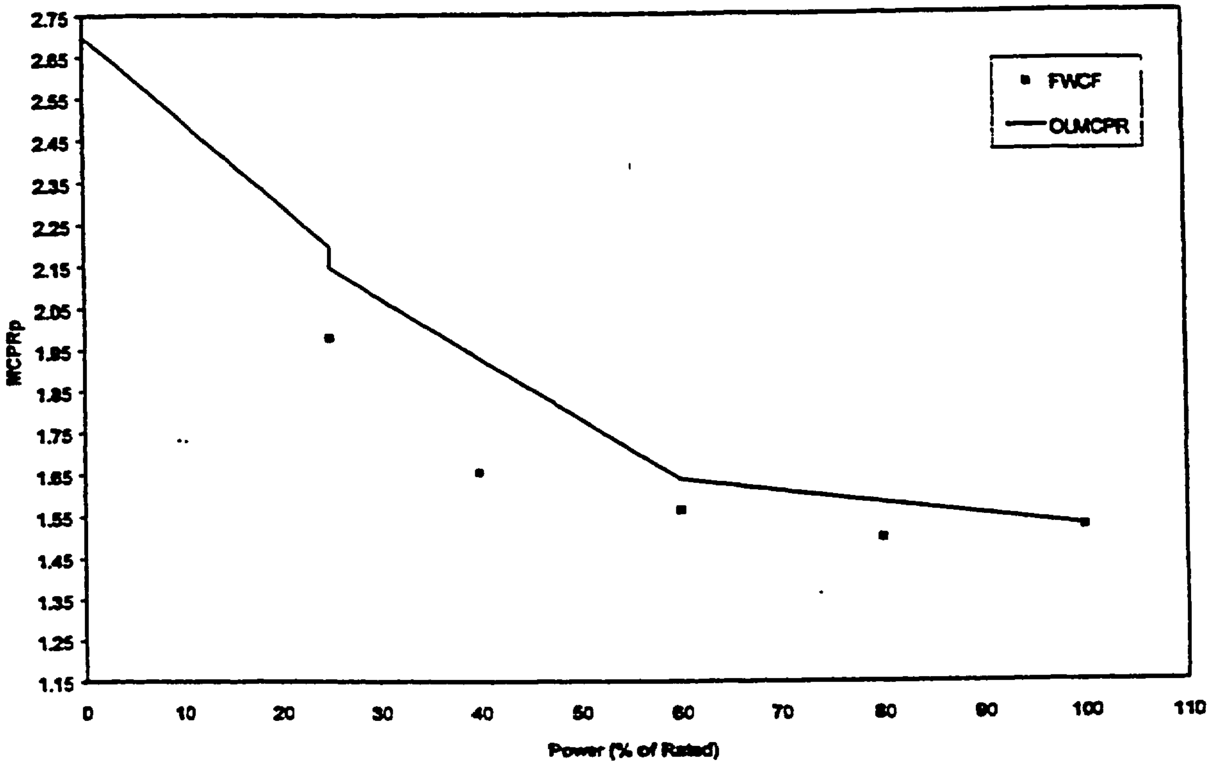
Power (%)	$MCPR_p$ Limit
100	1.44
60	1.55
25	2.05
25	2.20
0	2.70

Figure 6.1 Coastdown Turbine Bypass Valves Out-of-Service Power-Dependent MCPR Limits for ATRIUM-9B Fuel



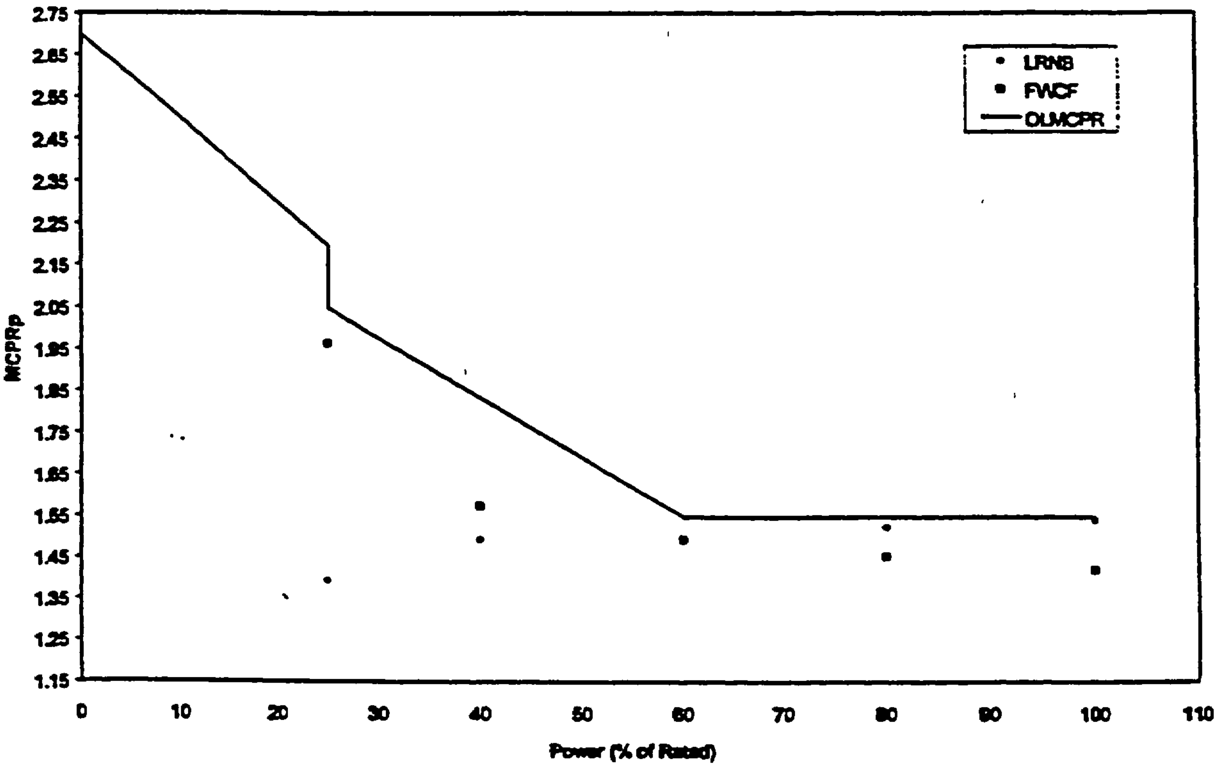
Power (%)	$LHGRFAC_p$ Multiplier
100	0.99
60	0.97
25	0.73
25	0.73
0	0.73

Figure 6.2 Coastdown Turbine Bypass Valves Out-of-Service Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



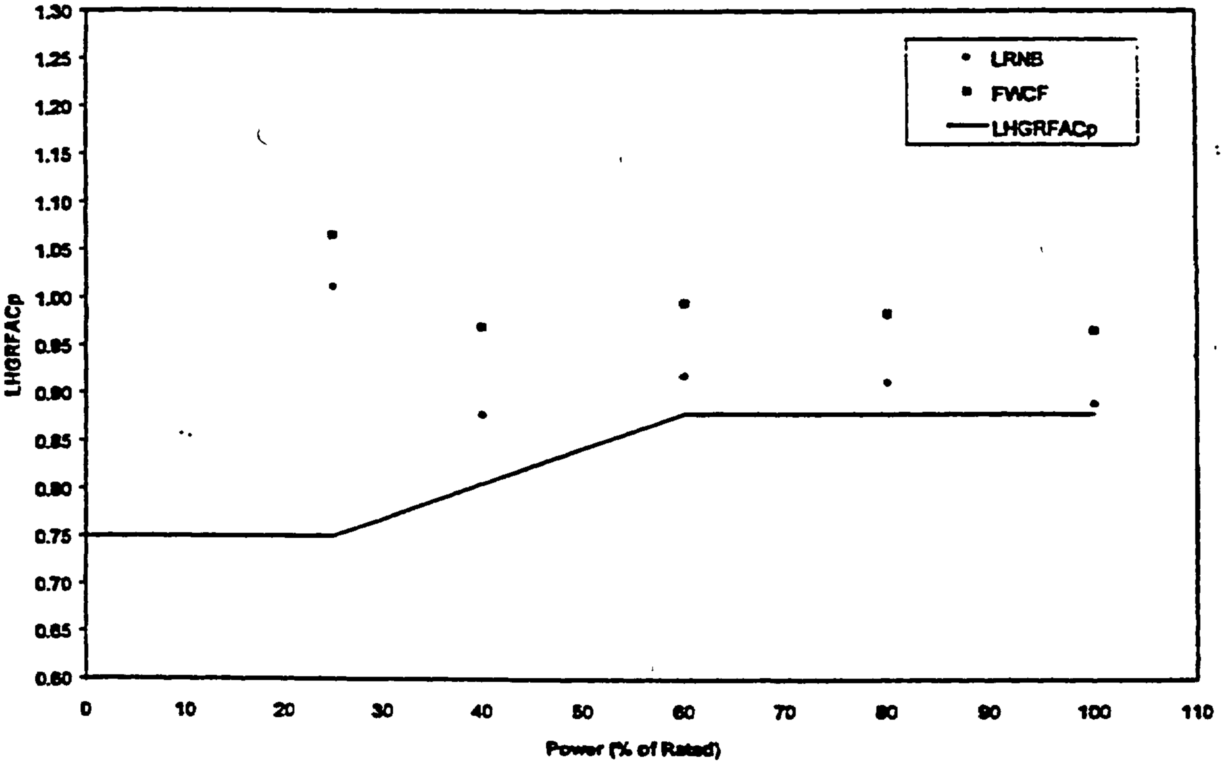
Power (%)	$MCPR_p$ Limit
100	1.53
60	1.64
25	2.15
25	2.20
0	2.70

Figure 6.3 Coastdown Turbine Bypass Valves Out-of-Service Power-Dependent MCPR Limits for GE9 Fuel



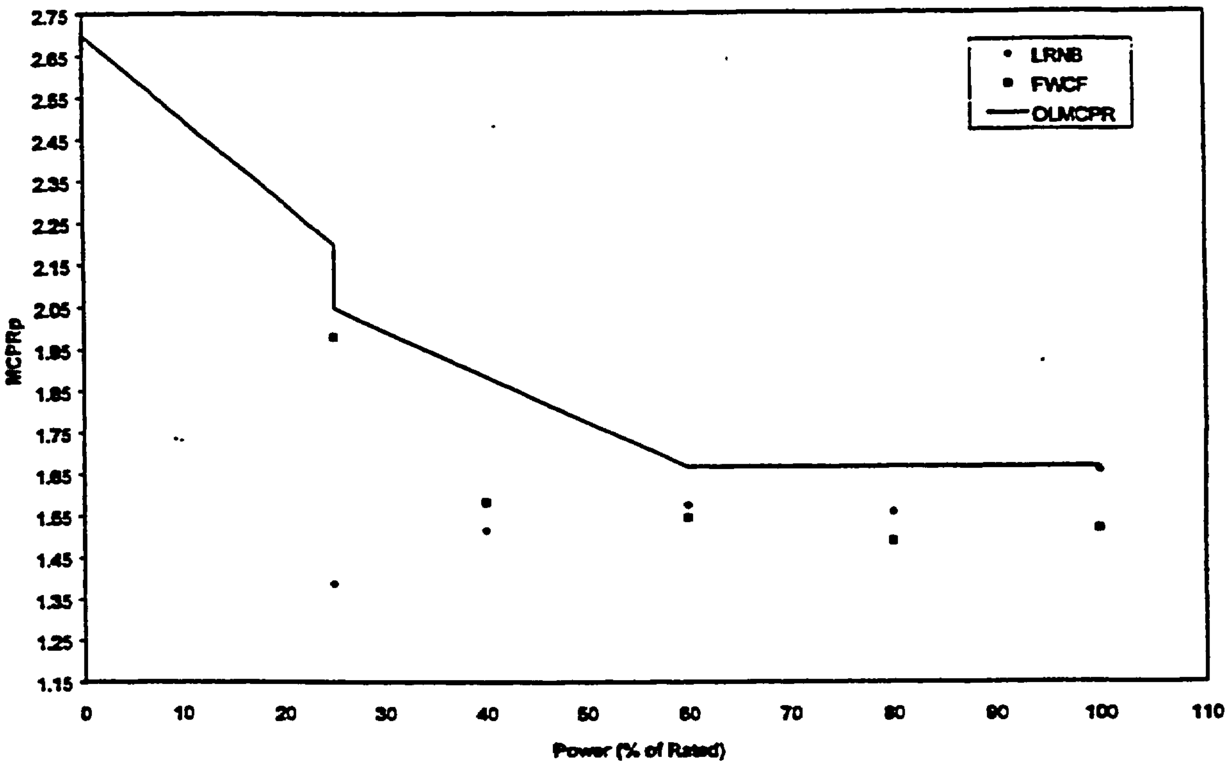
Power (%)	$MCPR_p$ Limit
100	1.55
60	1.55
25	2.05
25	2.20
0	2.70

Figure 6.4 Coastdown Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for ATRIUM-9B Fuel



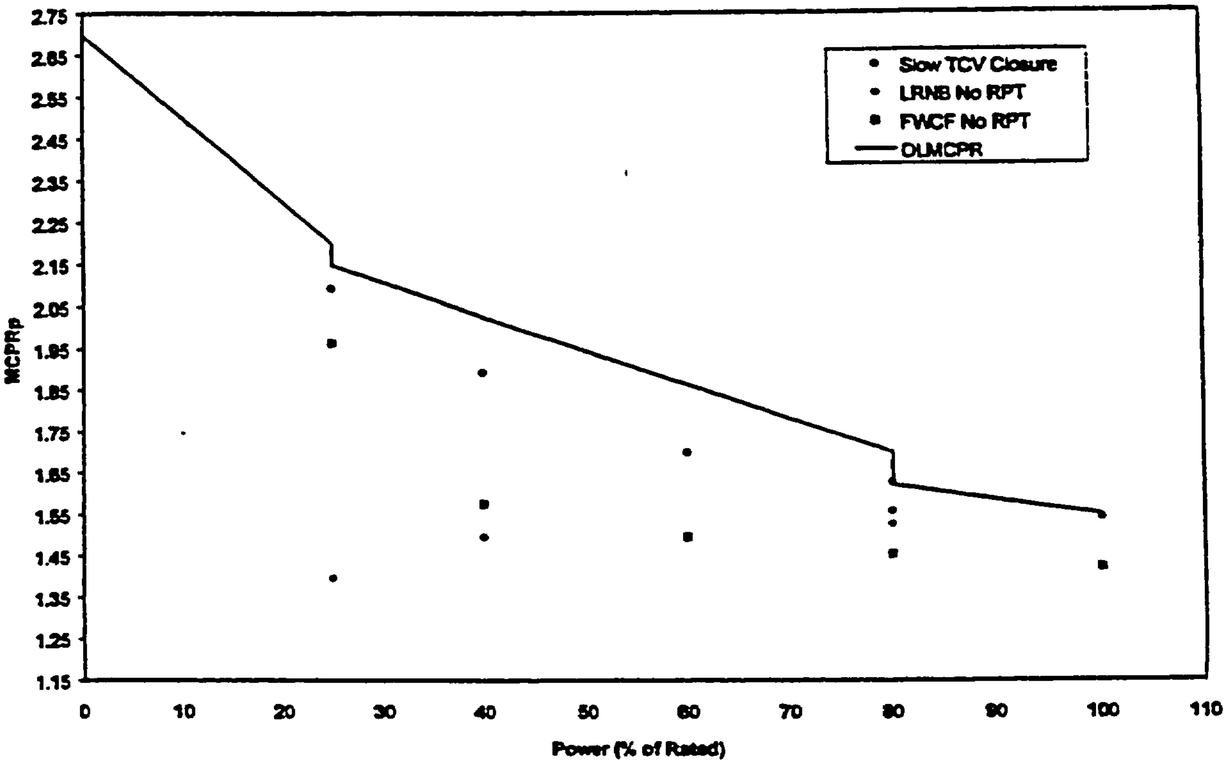
Power (%)	$LHGRFAC_p$ Multiplier
100	0.88
60	0.88
25	0.75
25	0.75
0	0.75

Figure 6.5 Coastdown Recirculation Pump Trip Out-of-Service Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



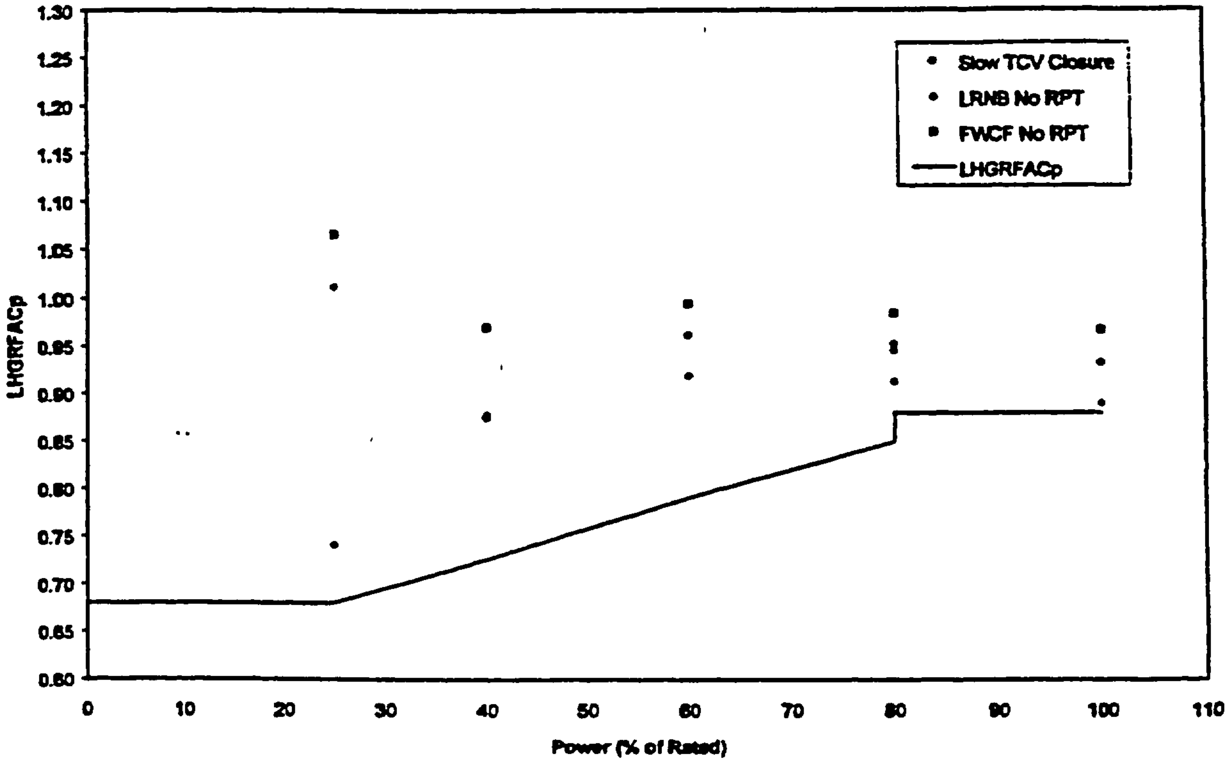
Power (%)	$MCPR_p$ Limit
100	1.67
60	1.67
25	2.05
25	2.20
0	2.70

Figure 6.6 Coastdown Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for GE9 Fuel



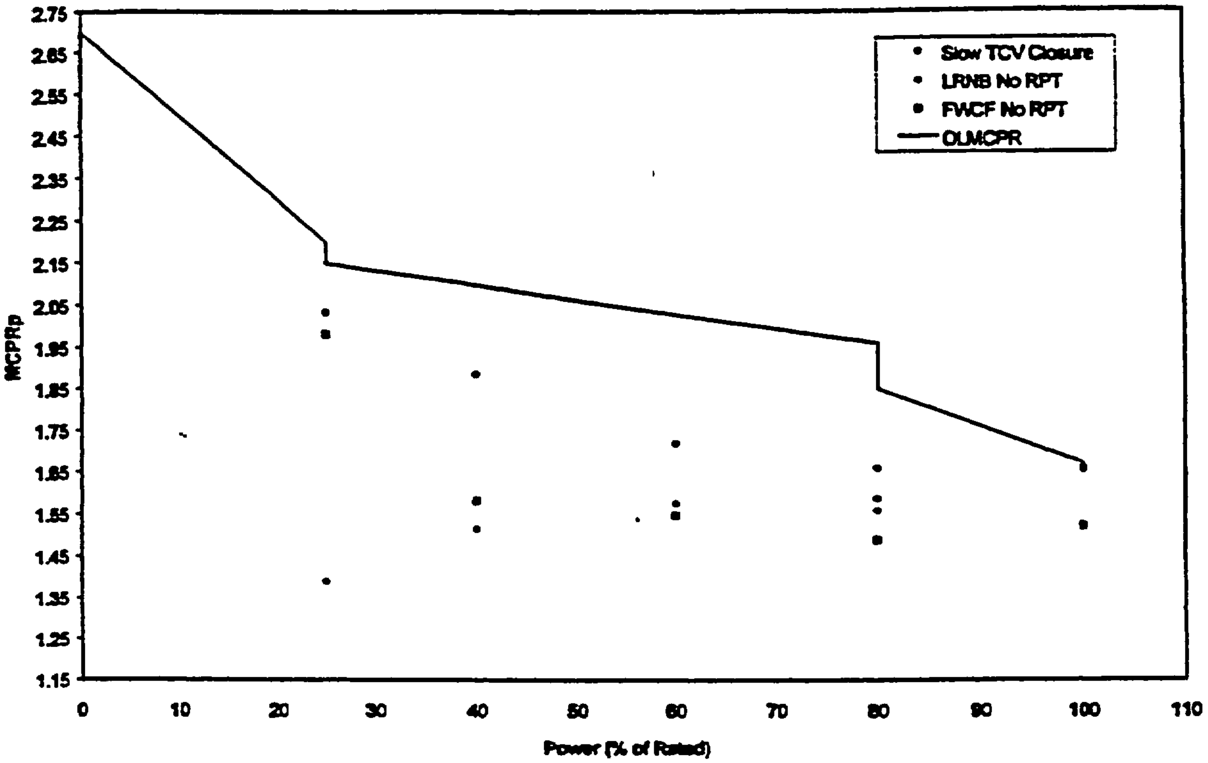
Power (%)	$MCPR_p$ Limit
100	1.55
80	1.62
80	1.70
25	2.15
25	2.20
0	2.70

Figure 6.7 Coastdown Turbine Control Valve Slow Closure and/or Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for ATRIUM-9B Fuel



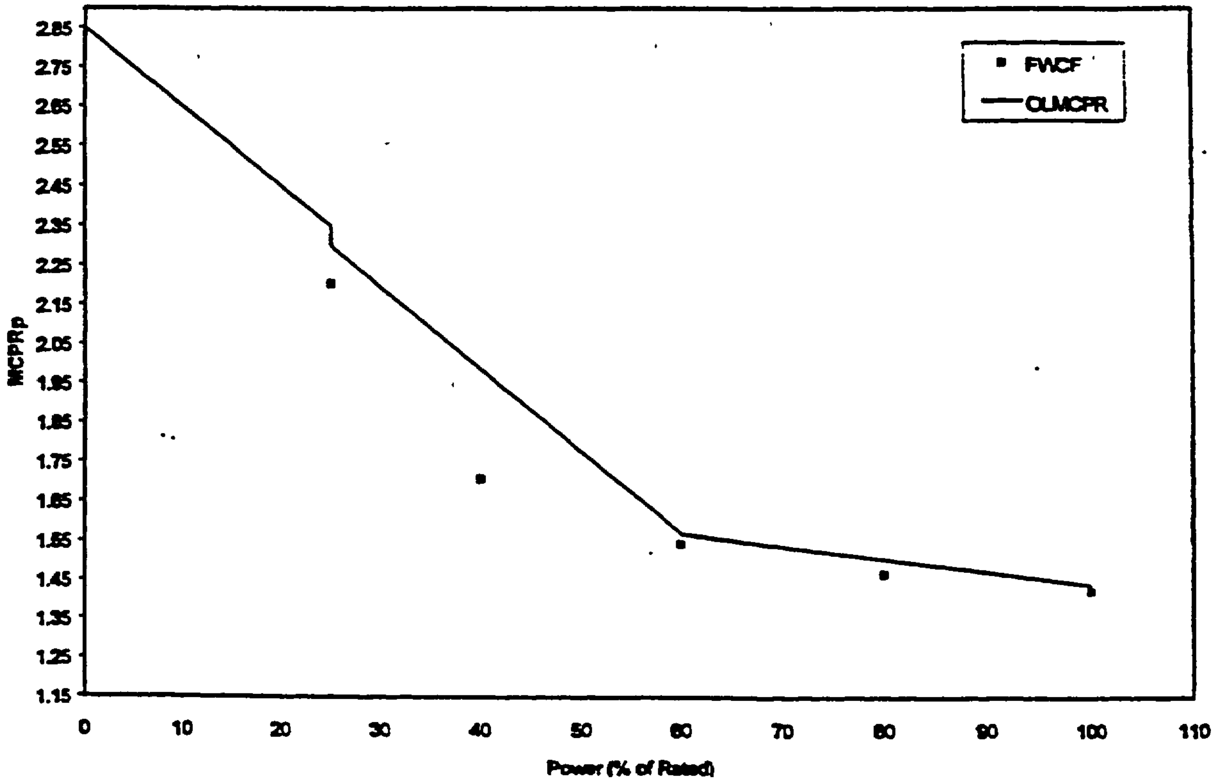
Power (%)	LHGRFAC$_p$ Multiplier
100	0.88
80	0.88
80	0.85
25	0.68
25	0.68
0	0.68

Figure 6.8 Coastdown Turbine Control Valve Slow Closure and/or Recirculation Pump Trip Out-of-Service Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



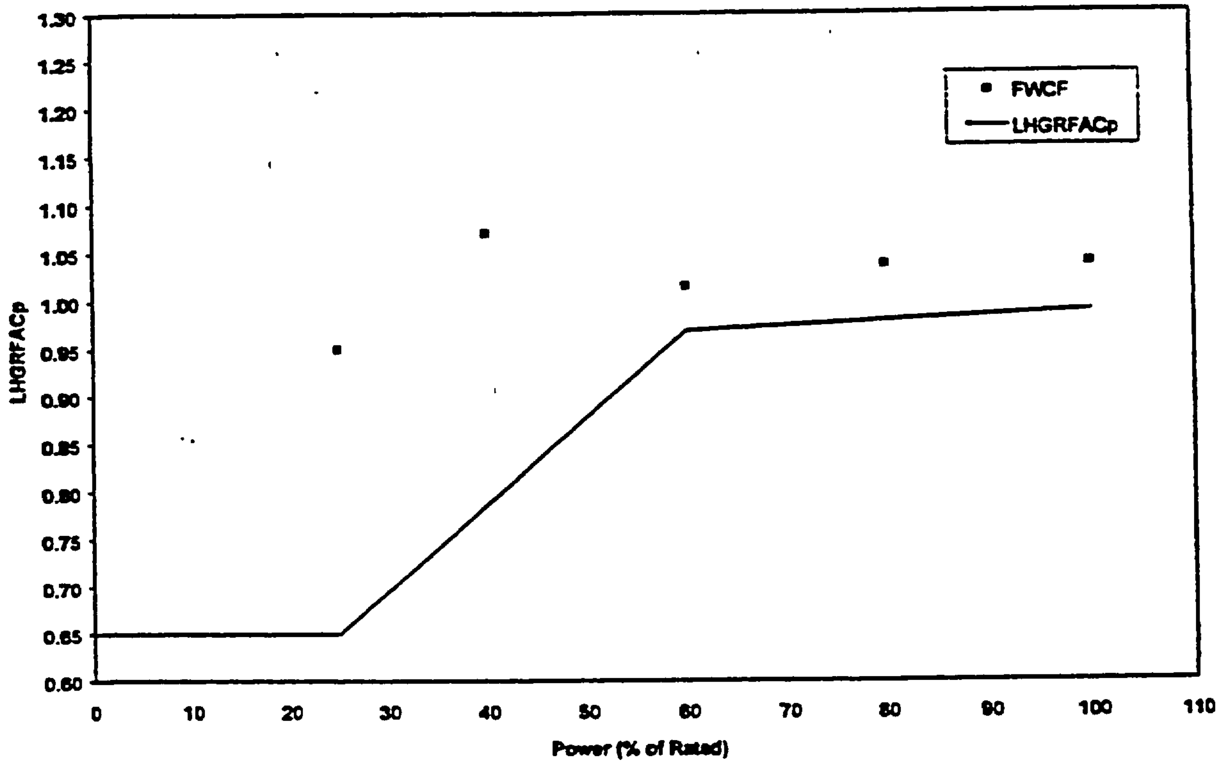
Power (%)	$MCPR_p$ Limit
100	1.67
80	1.85
80	1.96
25	2.15
25	2.20
0	2.70

Figure 6.9 Coastdown Turbine Control Valve Slow Closure and/or Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for GE9 Fuel



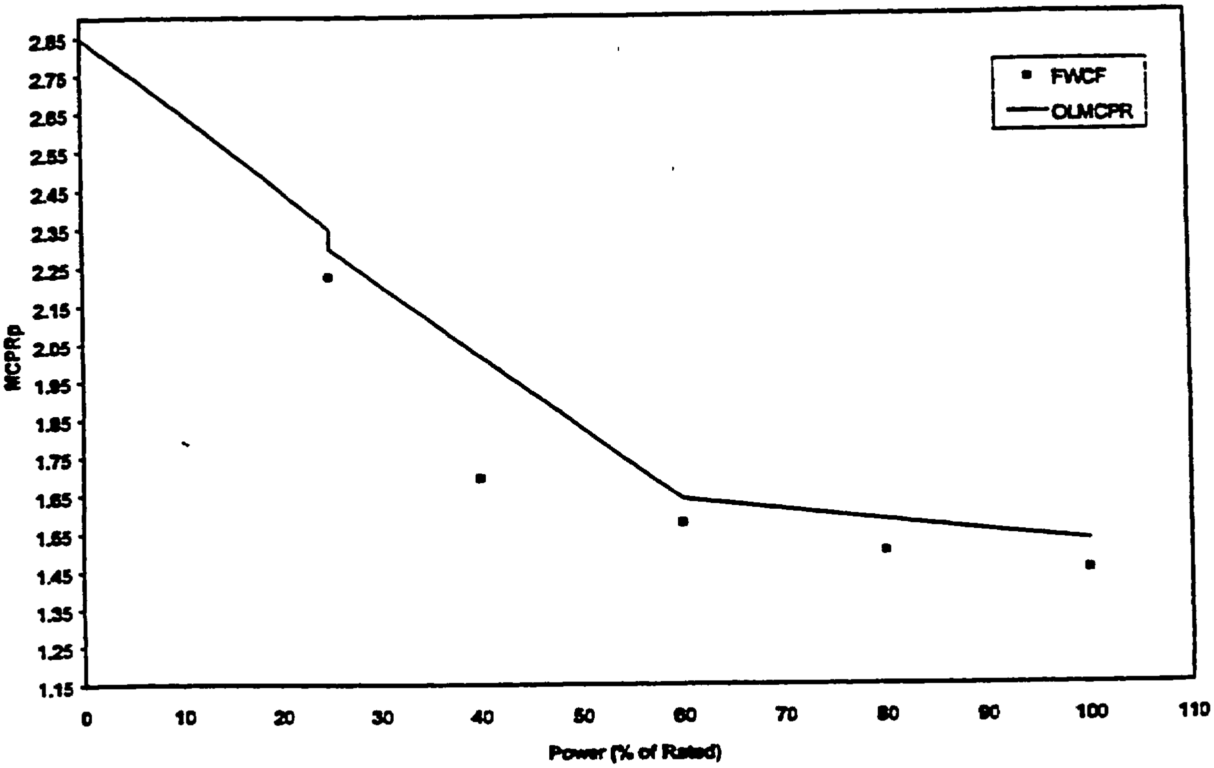
Power (%)	MCPR$_p$ Limit
100	1.44
60	1.57
25	2.30
25	2.35
0	2.85

Figure 6.10 FFTR/Coastdown Turbine Bypass Valves Out-of-Service Power-Dependent MCPR Limits for ATRIUM-9B Fuel



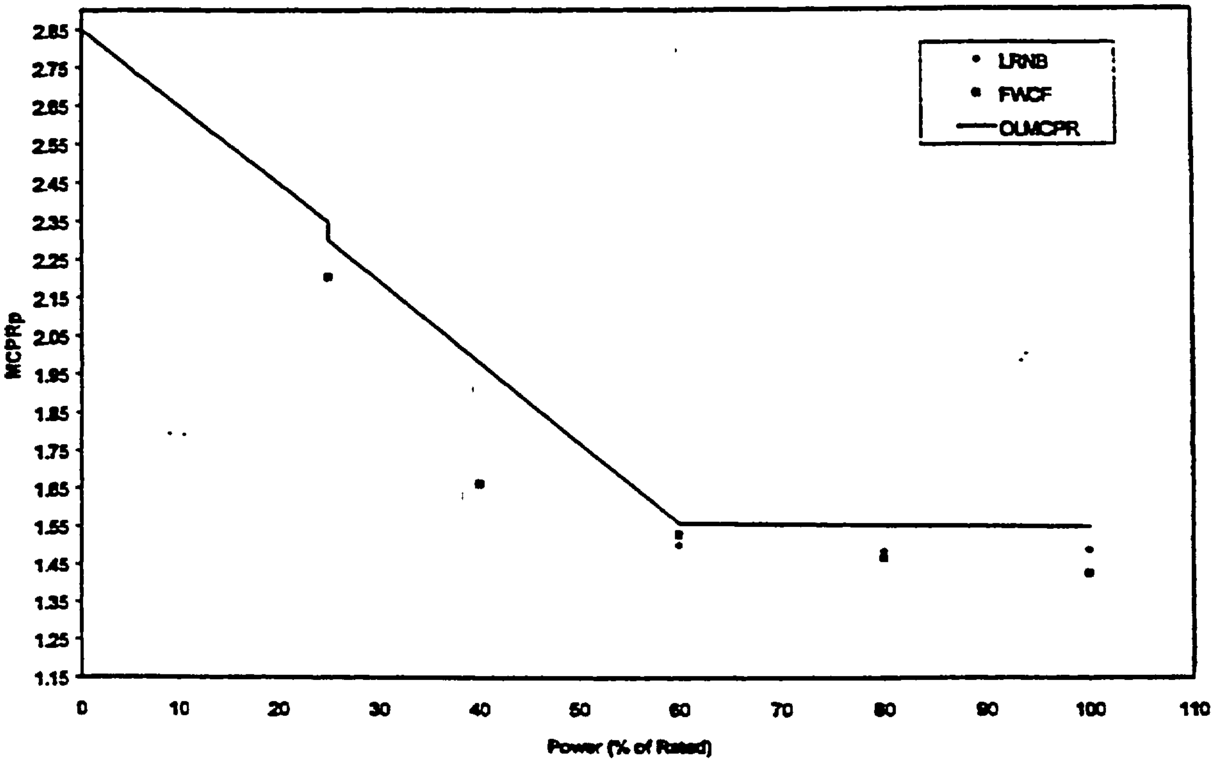
Power (%)	LHGRFAC$_p$ Multiplier
100	0.99
60	0.97
25	0.65
25	0.65
0	0.65

Figure 6.11 FFTR/Coastdown Turbine Bypass Valves Out-of-Service Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



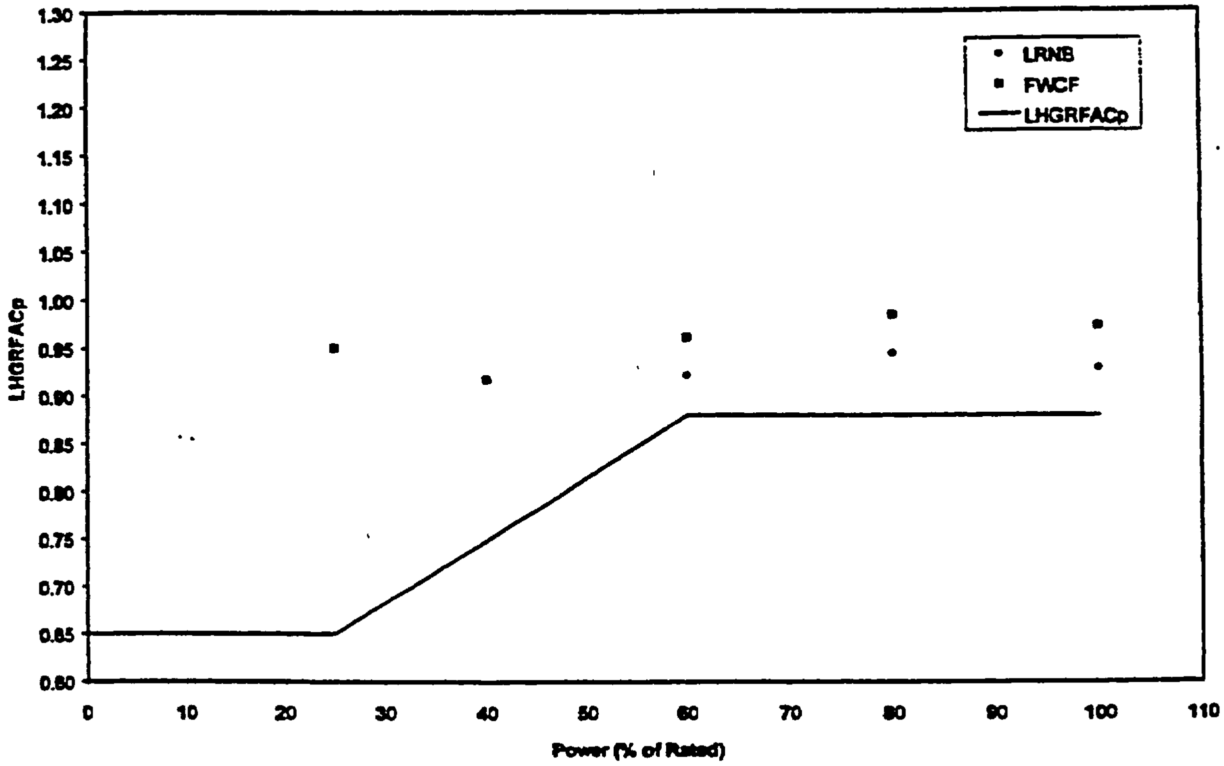
Power (%)	MCPR$_p$ Limit
100	1.53
60	1.64
25	2.30
25	2.35
0	2.85

Figure 6.12 FFTR/Coastdown Turbine Bypass Valves Out-of-Service Power-Dependent MCPR Limits for GE9 Fuel



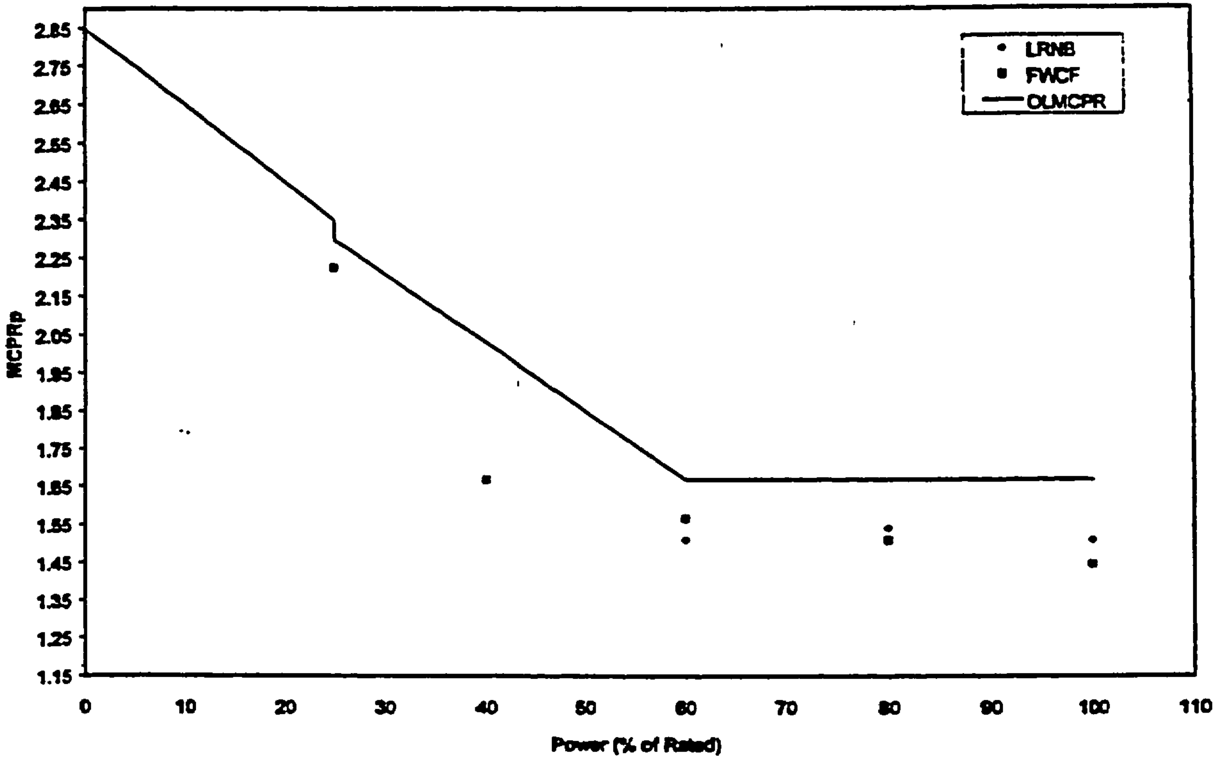
Power (%)	$MCPR_p$ Limit
100	1.55
60	1.56
25	2.30
25	2.35
0	2.85

Figure 6.13 FFTR/Coastdown Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for ATRIUM-9B Fuel



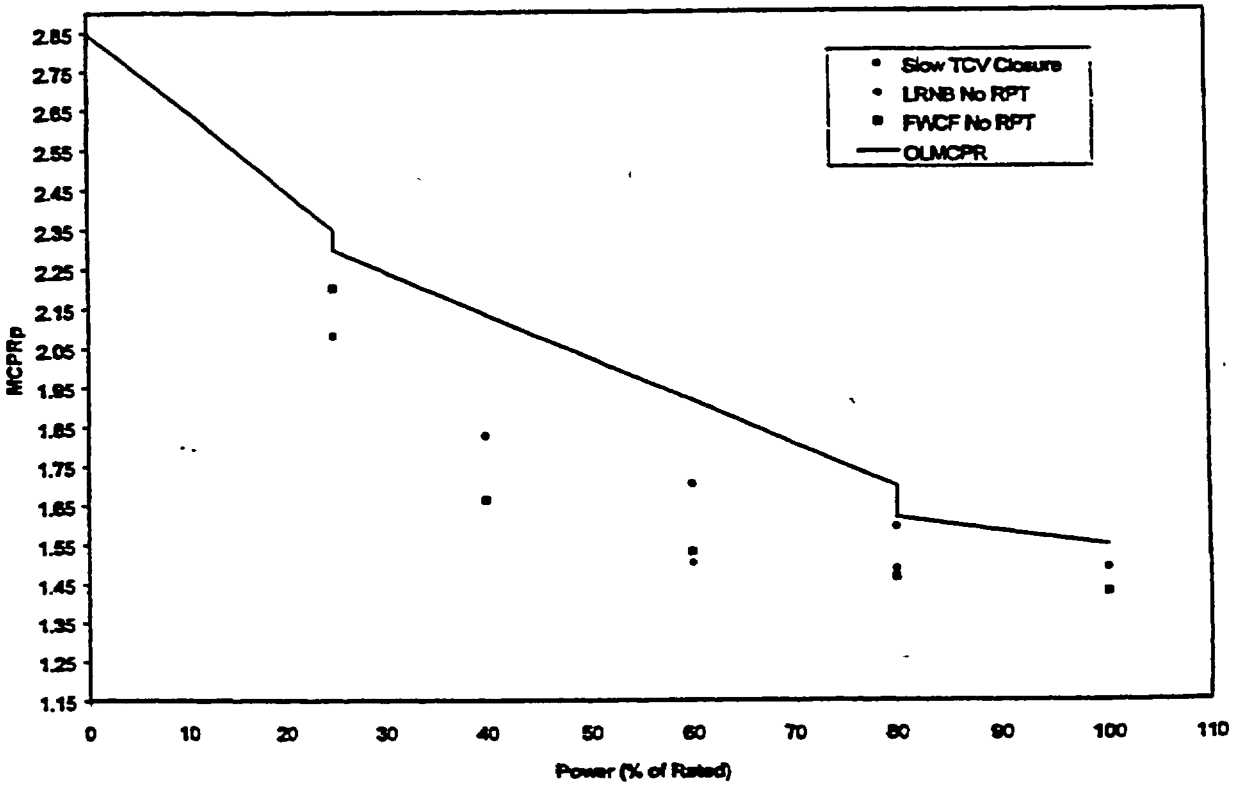
Power (%)	$LHGRFAC_p$ Multiplier
100	0.88
60	0.88
25	0.65
25	0.65
0	0.65

Figure 6.14 FFTR/Coastdown Recirculation Pump Trip Out-of-Service Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



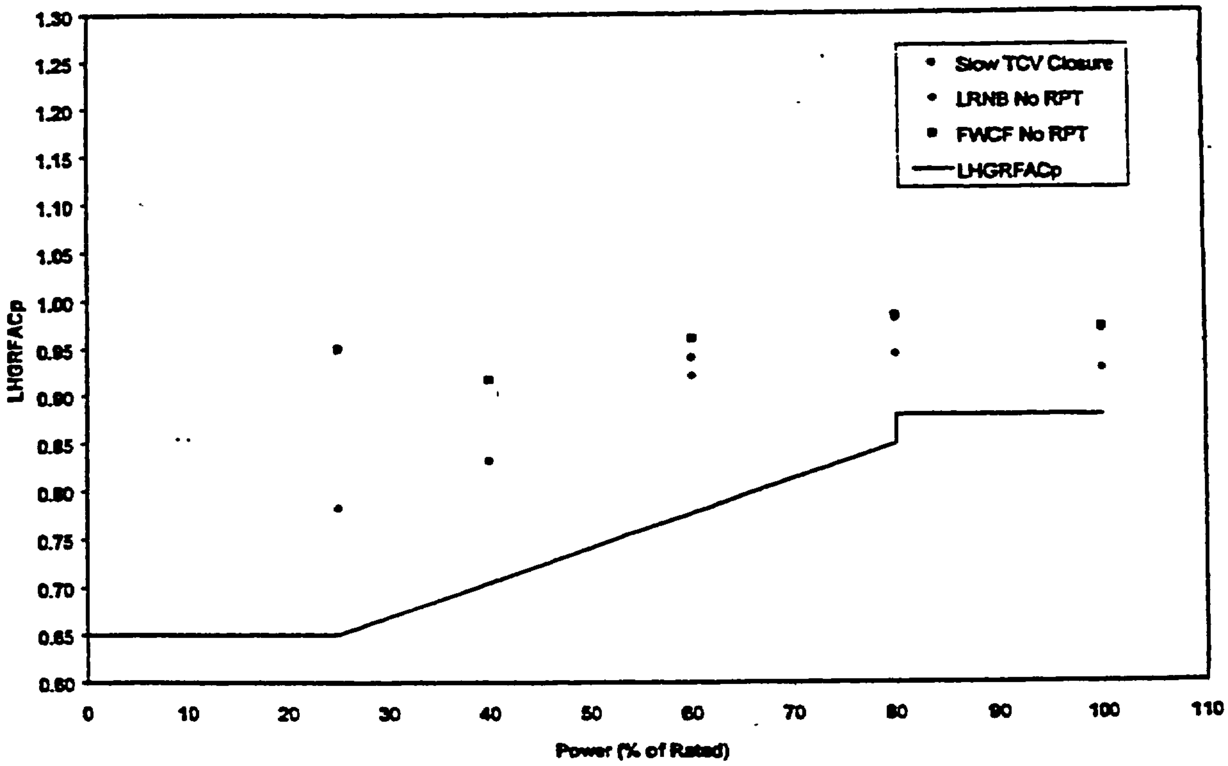
Power (%)	$MCPR_p$ Limit
100	1.67
60	1.67
25	2.30
25	2.35
0	2.85

Figure 6.15 FFTR/Coastdown Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for GE9 Fuel



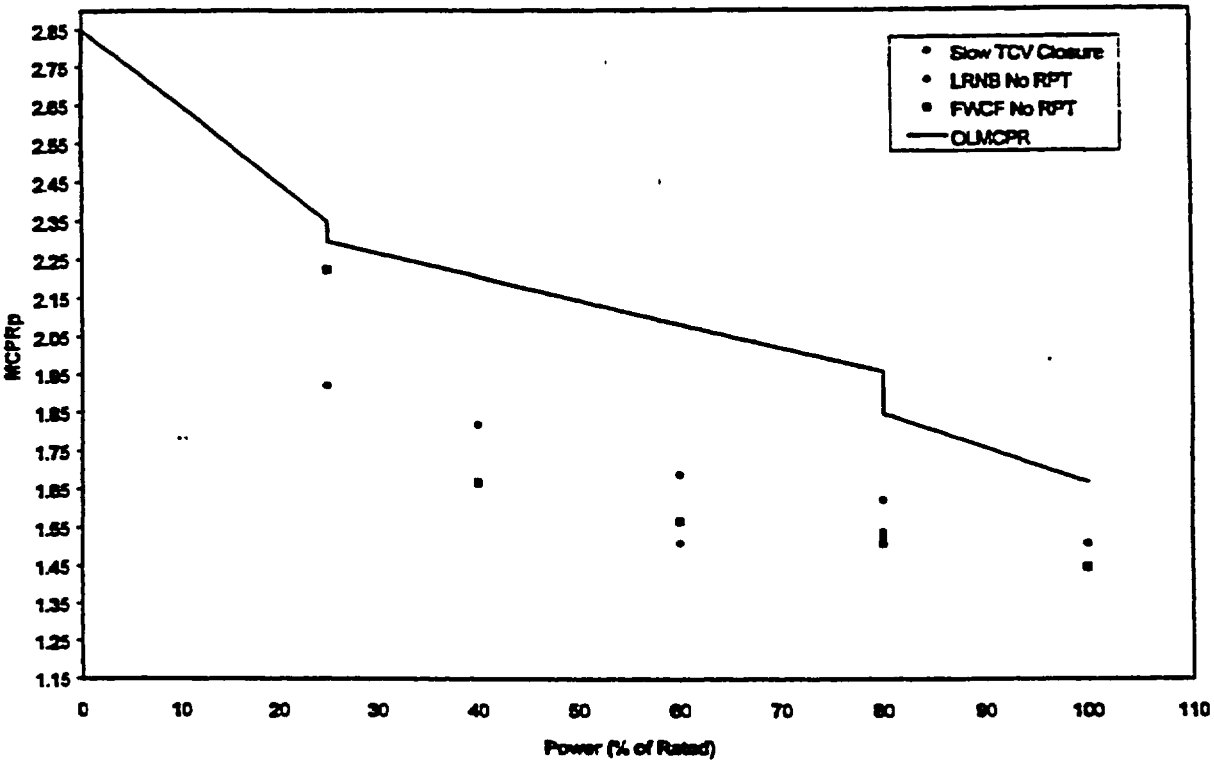
Power (%)	$MCPR_p$ Limit
100	1.55
80	1.62
80	1.70
25	2.30
25	2.35
0	2.85

Figure 6.16 FFTR/Coastdown Turbine Control Valve Slow Closure and/or Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for ATRIUM-9B Fuel



Power (%)	LHGRFAC$_p$ Multiplier
100	0.88
80	0.88
80	0.85
25	0.65
25	0.65
0	0.65

Figure 6.17 FFTR/Coastdown Turbine Control Valve Slow Closure and/or Recirculation Pump Trip Out-of-Service Power-Dependent LHGR Multipliers for ATRIUM-9B Fuel



Power (%)	$MCPR_p$ Limit
100	1.67
80	1.85
80	1.96
25	2.30
25	2.35
0	2.85

Figure 6.18 FFTR/Coastdown Turbine Control Valve Slow Closure and/or Recirculation Pump Trip Out-of-Service Power-Dependent MCPR Limits for GE9 Fuel

7.0 Maximum Overpressurization Analysis

This section describes the maximum overpressurization analyses performed to demonstrate compliance with the ASME Boiler and Pressure Vessel Code. The analysis shows that the safety/relief valves at LaSalle Unit 2 have sufficient capacity and performance to prevent the pressure from reaching the pressure safety limit of 110% of the design pressure.

7.1 *Design Basis*

The MSIV closure analysis was performed with the SPC plant simulator code COTRANSA2 (Reference 4) at a power/flow state point of 102% of uprated power/105% flow. Reference 9 indicates that an EOFP + 1000 MWd/MTU exposure is limiting for the overpressurization analysis. The following assumptions were made in the analysis.

- The most critical active component (direct scram on valve position) was assumed to fail. However, scram on high-neutron flux and high-dome pressure is available.
- At ComEd's request, analyses were performed to determine the minimum number of the highest set point SRVs required to meet the ASME and Technical Specification pressure limits. It was determined that having the 10 highest set point SRVs operable will meet the ASME and Technical Specification pressure limits. In order to support operation with 1 SRV out-of-service, the plant configuration needs to include at least 11 SRVs. As per ASME requirements, the SRVs are assumed to operate in the safety mode.
- TSSS insertion times were used.
- The initial dome pressure was set at the maximum allowed by the Technical Specifications (1035 psia).
- An MSIV closure time of 1.1 seconds was assumed in the analysis.
- EOC RPT is assumed inoperable; ATWS (high-dome pressure) RPT is available.

7.2 *Pressurization Transients*

Results of analysis for the MSIV closure event initiated at 102% power/105% flow are presented in Table 7.1. Figures 7.1–7.5 show the response of various reactor plant parameters to the MSIV closure event. The maximum pressure of 1346.2 psig occurs in the lower plenum at approximately 4.4 seconds. The maximum dome pressure of 1319.9 psig occurs at 4.6 seconds. The results demonstrate that the maximum vessel pressure limit of 1375 psig and dome pressure limit of 1325 psig are not exceeded.

Table 7.1 ASME Overpressurization Analysis Results
102%P/105%F

Event	Peak Neutron Flux (% rated)	Peak Heat Flux (% rated)	Maximum Vessel Pressure Lower-Plenum (psig)	Maximum Dome Pressure (psig)
MSIV closure	373.7	136.6	1346.2	1319.9

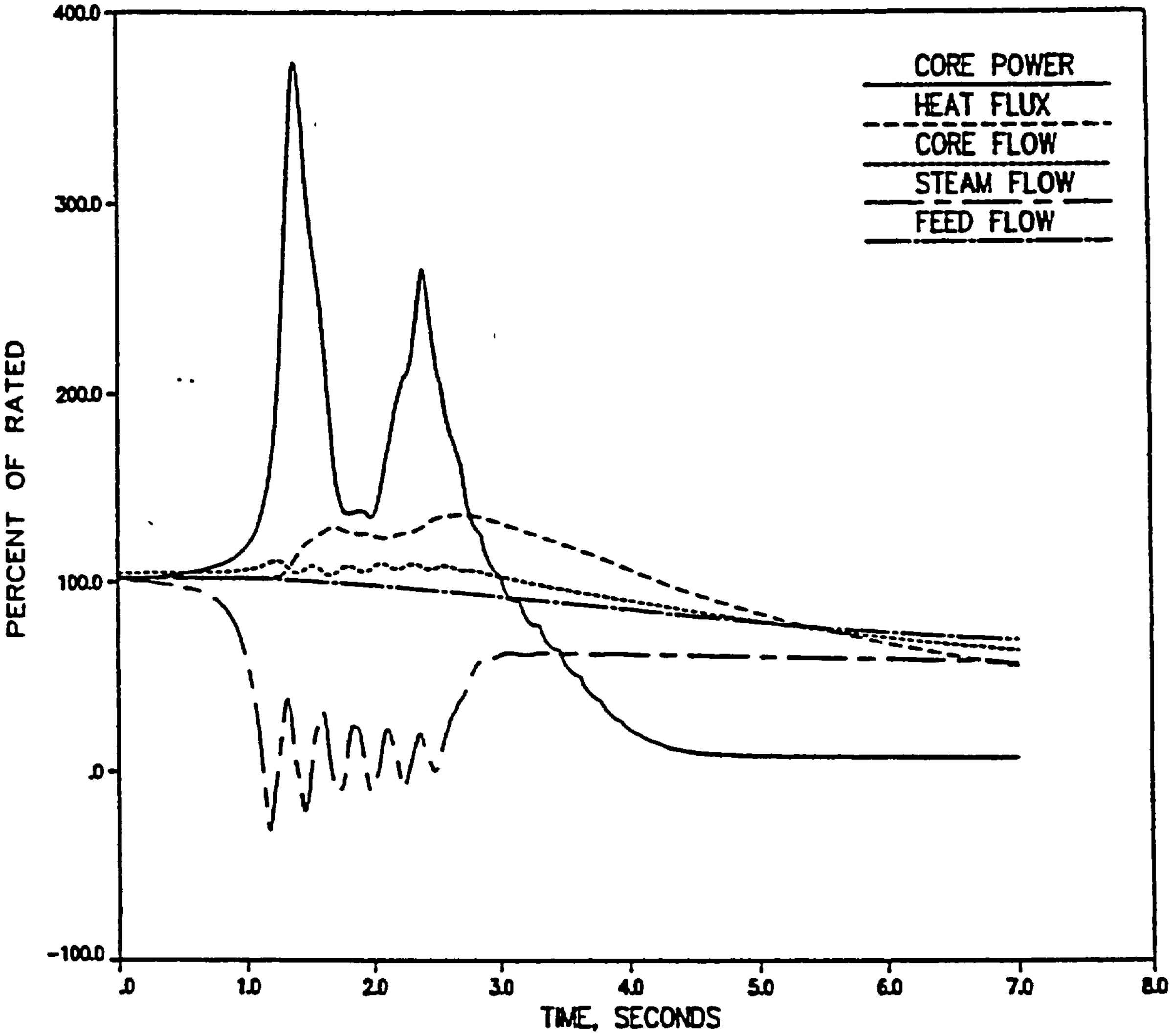


Figure 7.1 Overpressurization Event at 102/105 - MSIV Closure Key Parameters

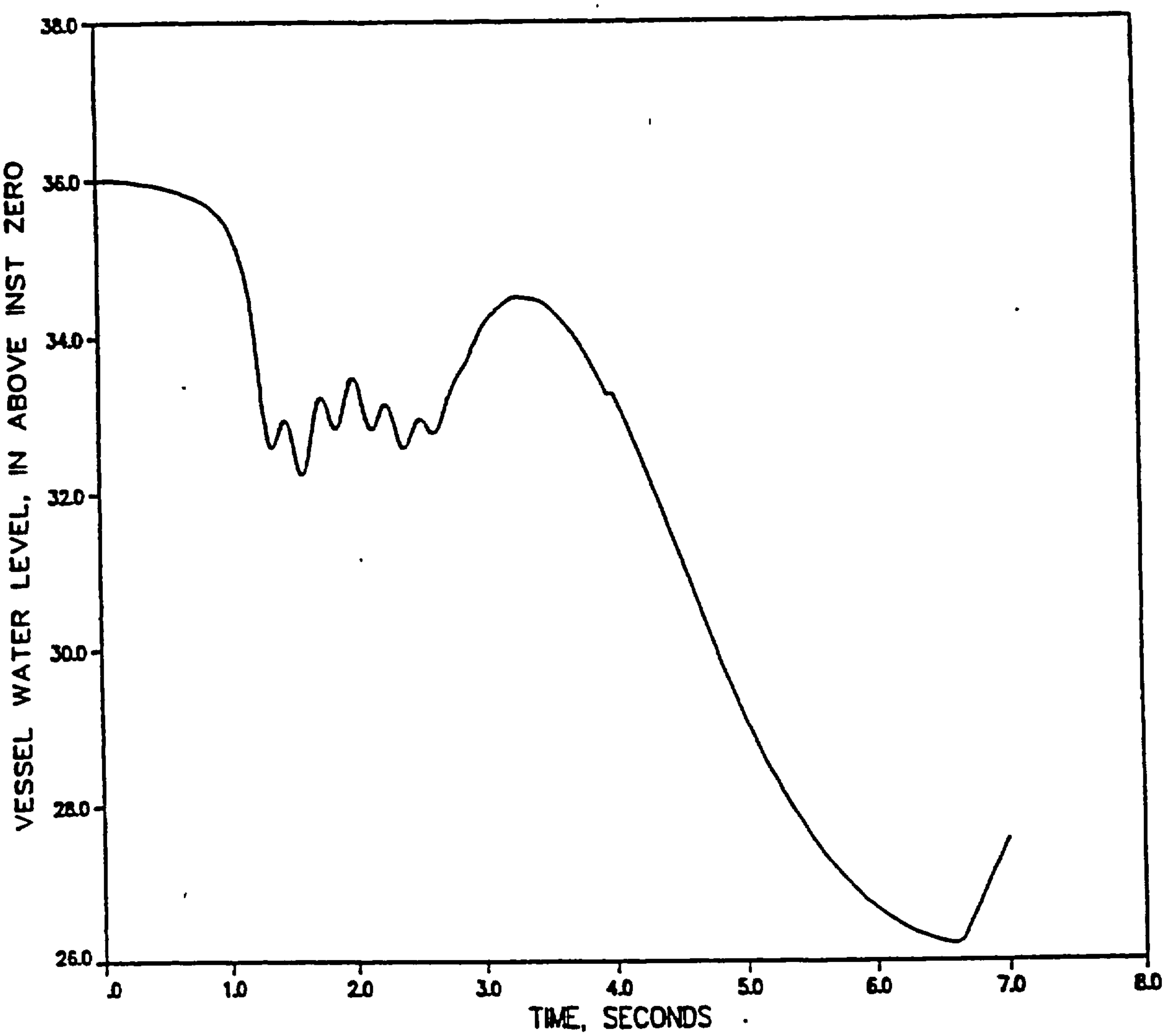


Figure 7.2 Overpressurization Event at 102/105 - MSIV Closure Vessel Water Level

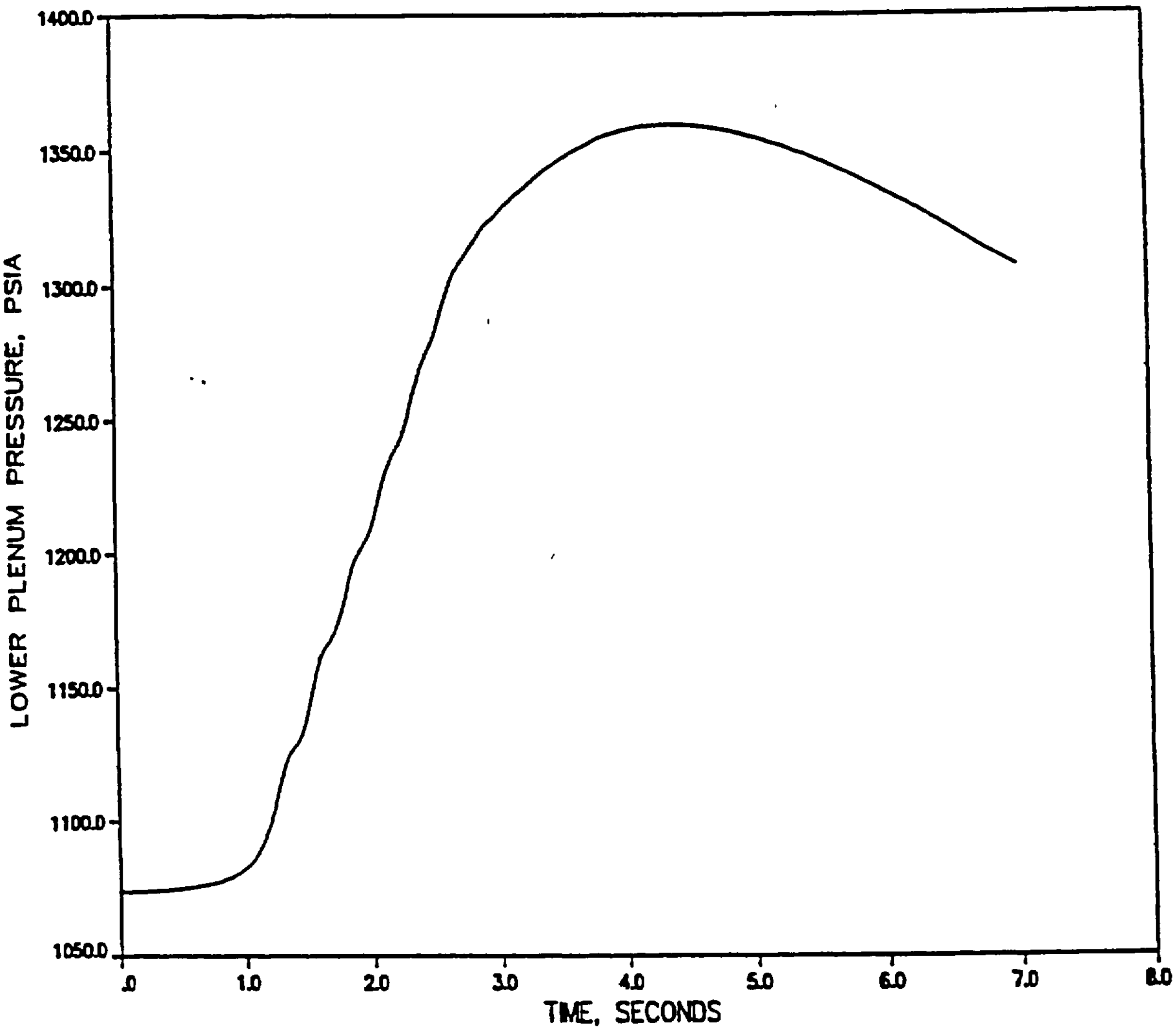


Figure 7.3 Overpressurization Event at 102/105 -
MSIV Closure Lower-Plenum Pressure

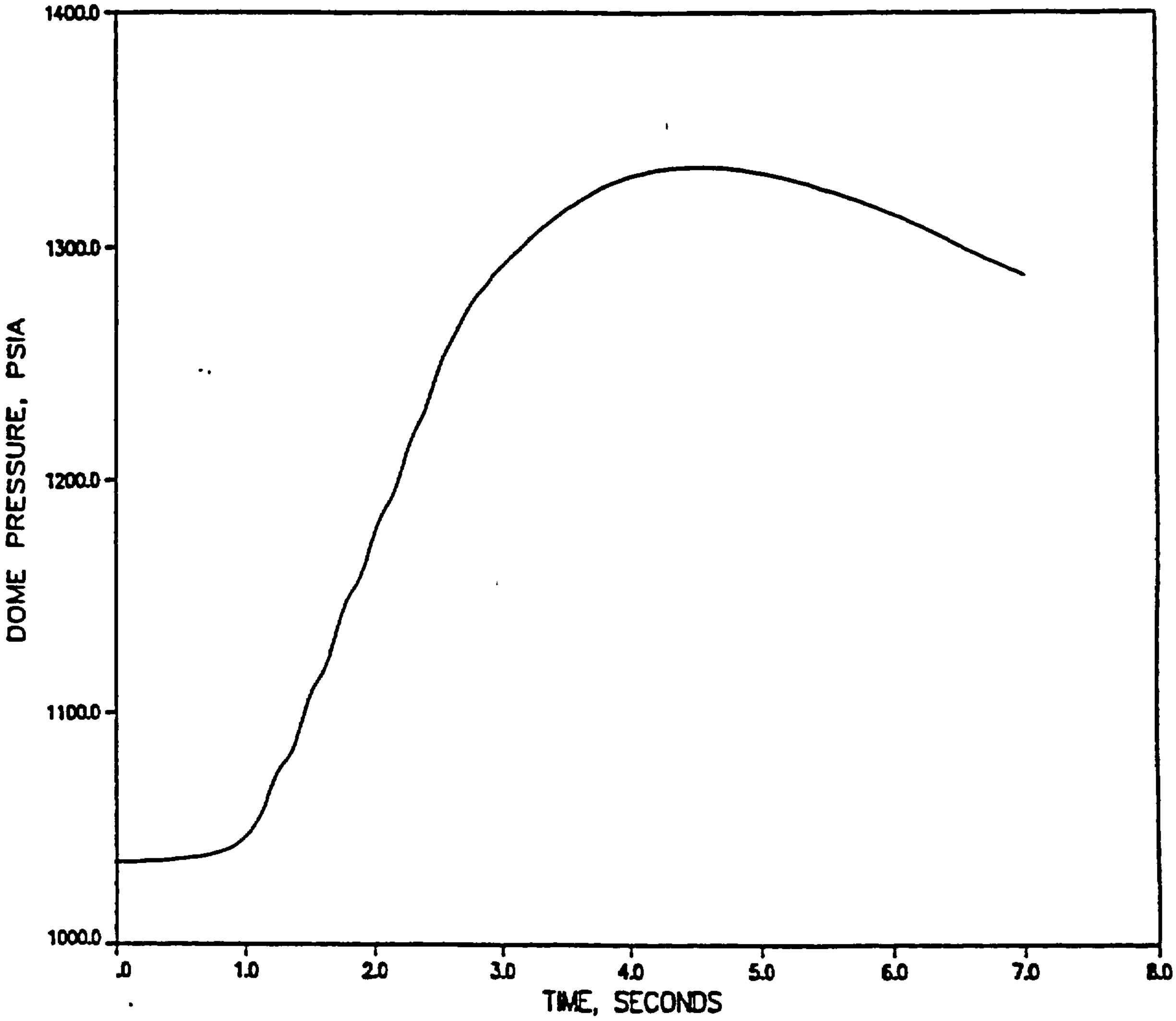
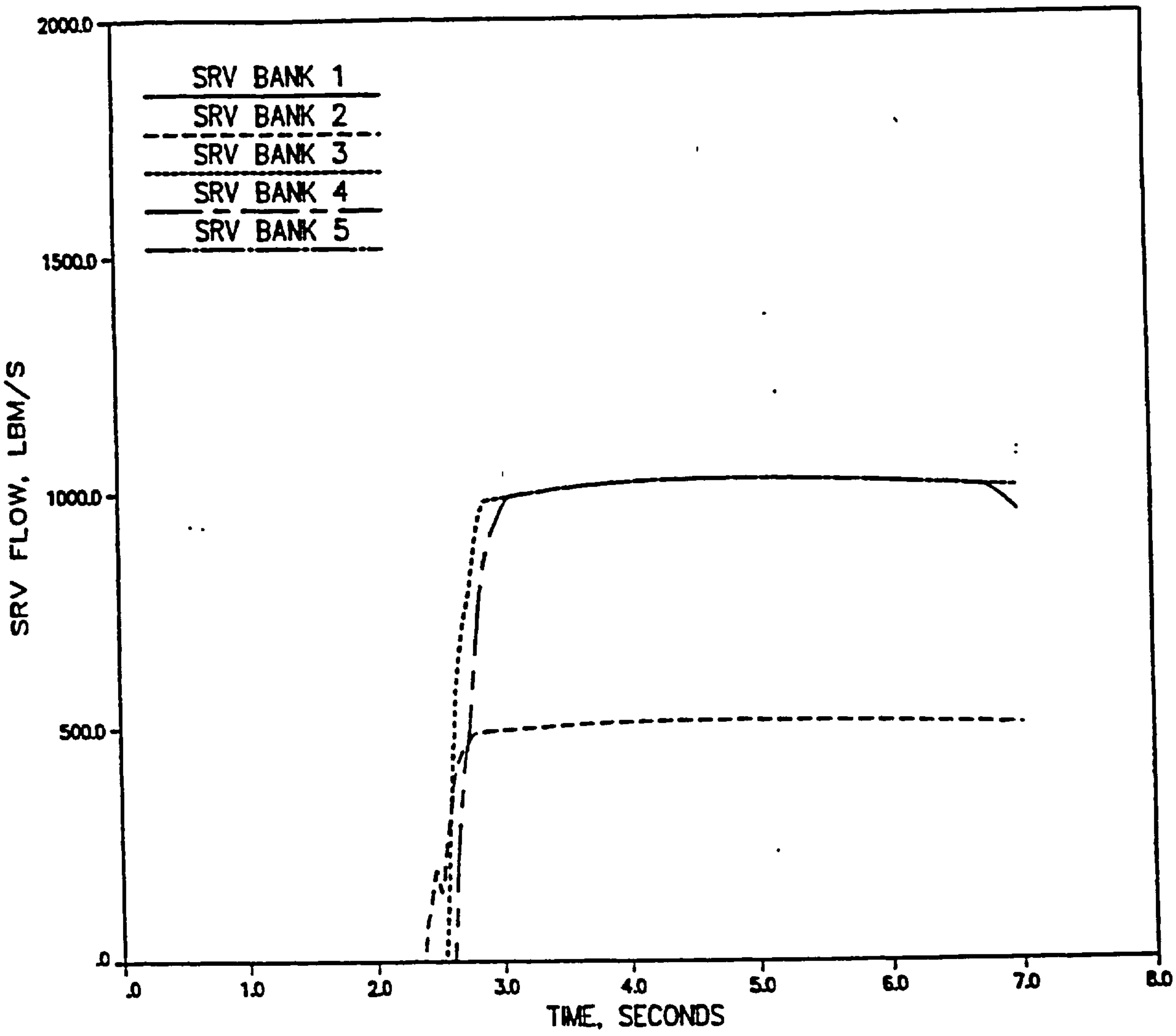


Figure 7.4 Overpressurization Event at 102/105 - MSIV Closure Dome Pressure



Bank	Number of SRVs	Opening Pressure (psia)
1	0	NA
2	2	1235.3
3	4	1245.6
4	4	1255.9
5	0	NA

Figure 7.5 Overpressurization Event at 102/105 - MSIV Closure Safety/Relief Valve Flow Rates

8.0 References

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Appendix A Power-Dependent LHGR Limit Generation

The linear heat generation rate (LHGR) operating limit is established to ensure that the steady-state LHGR (SSLHGR) limit is protected during normal operation and that the protection against power transient (PAPT) LHGR limit is protected during an anticipated operational occurrence (AOO). To ensure that the LHGR operating limit provides the necessary protection during operation at off-rated conditions, adjustments to the SSLHGR limits may be necessary. These adjustments are made by applying power and flow-dependent LHGR multipliers ($LHGRFAC_p$ and $LHGRFAC_f$, respectively) to the SSLHGR limit. The LHGR operating limit (LHGROL) for a given operating condition is determined as follows:

$$LHGROL = \min [LHGRFAC_p \times SSLHGR, LHGRFAC_f \times SSLHGR]$$

The power-dependent LHGR multipliers ($LHGRFAC_p$) are determined using the heat flux excursion experienced by the fuel during AOOs. The heat flux ratio (HFR) is defined as the ratio of the maximum nodal transient heat flux over the maximum nodal heat flux at the initiation of the transient. The HFR provides a measure of the LHGR excursion during the transient. The PAPT limit divided by the SSLHGR limit provides an upper limit for the HFR to ensure that the PAPT LHGR limit is not violated during an AOO. $LHGRFAC_p$ is set equal to the minimum of the PAPT/SSLHGR ratio over HFR, or 1.0. Based on the ATRIUM-9B LHGR limits presented in Reference A-1, $LHGRFAC_p$ is established as follows:

$$\frac{PAPT}{SSLHGR} = 1.35$$

$$HFR = \frac{Q_{maxt}}{Q_{max0}}$$

$$LHGRFAC_p = \min \left[\frac{1.35}{HFR}, 1.0\right]$$

In some cases, the established MCPR limit precludes operation at the SSLHGR limit. This allows for a larger LHGR excursion during the transient without violating the PAPT LHGR limit. This approach was used to provide less restrictive $LHGRFAC_p$ multipliers for some cases.

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